ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

GENERAL LIBRARY FEB 6 1920 UNIV. OF MICH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2

VOL. CVIII.—No. 2817.] *LONDON: FRIDAY, DECEMBER 26, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY INLAND POST ... 11d.

Aveling & Porter, Ltd.,
ROCHESTER, KENT.
(Branch of Agricultural & General Engineers, Ltd.)
STEAM ROLLERS. ROAD SCARIFIERS,
CONVERTIBLE TRACTION ENGINES AND ROLLERS. 7667
TRACTION ENGINES. TRACTORS.
STEAM CULTIVATING MACHINERY.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS.
See Advertisement, page 33, last week.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

John H. Wilson & Co., Ltd.
Birkenhead.
See Illustrated Advertisement Page 17, Dec. 12.

Locomotive Shunting Cranes
Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS WINDLASSES, WINCHES, and DECK MACHINERY.
8770
LISTS OF STANDARD SIZES ON APPLICATION.
London Office
15, VICTORIA STREET, S.W. 1.

Craig & Donald, Ltd., Machine
TOOL MAKERS, JOHNSTONE, near Glasgow.
For class of Machine Tools see our Illustrated Advertisement every alternate week. 1358

CHANTIERS & ATHLIERS
Augustin-Normand
97, rue de Perrey—LE HAVRE (France). 2890
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Electric Lifts
(UP TO 35 TONS.)
8143
S. H. HENYWOOD & CO., LTD., RHDDISH.

Steam Hammers (with or without guides), Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 7364
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

Brett's Patent Lifter Co. LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 7364

Telegrams—"Cylinders," Birmingham.
Weldless-Steel Tubes
for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. 8179

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 7768
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3561
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17, Dec. 19. 7263

Electric Cranes.
8143
S. H. HENYWOOD & CO., LTD., RHDDISH.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 80, Wellington Street, Glasgow. 7868

Separators
— FOR —
EXHAUST STEAM TURBINES COMPRESSED AIR, &c.
STEAM DRYERS,
METALLIC PACKINGS.
Princeps & Co.,
SHEFFIELD. 6686

Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 7260

Excavators.
FROM 50 TO 600 YARDS PER HOUR.
D. Whitaker,
1, UNION STREET, LEICESTER. 7095

AERIAL ROPEWAYS, CABLEWAYS, CRANES.
Steel Castings.
7379
See displayed advertisement every alternate week.
JOHN M. HENDERSON & CO., ABERDEEN.

"Spencer-Hopwood" Patent Boilers.
Sole Makers:
W. H. SPENCER & CO., HITCHIN, HERTS.
See page 18, Dec. 19. 7454

S. Sokal, CHARTERED PATENT AGENT,
1, Great James Street, Bedford Row, London, W.C.1
T. N. 4515 Holborn. 7905

THE GLASGOW ROLLING STOCK AND PLANT WORKS
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY AND TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Od 3382

Iron and Steel
Tubes and Fittings.
6930
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 101.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } ROW'S PATENTS.
CONDENSERS, AIR HEATERS,
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

Tubes and Fittings,
IRON AND STEEL
Stewarts and Lloyd's, Ltd.,
41, OSWALD ST., GLASGOW.
BROAD STREET CHAMBERS, BIRMINGHAM; and LONDON OFFICE—
WINCHESTER HOUSE, OLD BROAD STREET, E.C.
LONDON WAREHOUSE—167, UPR. THAMES ST., E.C.
LIVERPOOL WAREHOUSE—63, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPSCOTE STREET, and 10, COLESHILL STREET.
See Advertisement page 28. 7268

Die Finished Castings
ensure rapid production and reduce prime cost by eliminating machining operations.
Write for illustrations to AERATORS LTD., Edmonton, London, N. 18.

PLIABLE, NON-RUSTING
Metallic Hose-Covering
to protect & strengthen tubing for all pressures and purposes. As supplied for H.M. Govt.—AERATORS LTD., Edmonton, London, N. 18.

Micrometers
FROM
Stock.
THE
Newall Engineering Co.
(Proprietors, Peter Hooker, Ltd.),
LONDON, E. 17. 7824

Locomotive Traversers
(ELECTRIC).
8143
S. H. HENYWOOD & CO., LTD., RHDDISH.

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.
Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD, LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 15. 7077

Rubber MANUFACTURERS.
Hose Suction and Fire.
GUTTA PERCHA & RUBBER, LIMITED, Toronto - - - Canada. 7535

Patent
See's Hydro-Pneumatic Ash Ejector.
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4836

Diesel Driven Generators,
400-500 Kw., D.C., 500 or 250 Volts, 250 R.P.M., in excellent condition. Low price.
Engines and Dynamos could be sold separately.
Also TWO 500 Kw. Parsons TURBINES, 220 Volts, D.C., complete with Spare Armature and Condenser.
JENNINGS,
West Walls, Newcastle-on-Tyne. 7969

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES,
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 7312

Tel.: "SONDELA." P.O. BOX 550.
J. E. Parker,
M.I.Mech.E., M.A.I.M.E.,
CONSULTING ENGINEER, 8039
Pretoria, S.A.
Mining. Industrial. Mechanical.

Yarrow Patent
Water-Tube Boilers.
7769
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

John Bellamy Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS, 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3382

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 59, Dec. 19. 3409

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 7059
See Full Page Advt., page 83, Dec. 12.

Taylor & Challen
Presses.
8195
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement, Dec. 12.

Steel Castings.
THOMAS SUMMERSON & SONS, LTD., DARLINGTON. 7905

Electric Transporters.
S. H. HENYWOOD & CO., LTD., 8143
RHDDISH.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Od 3547
Registered Offices: 108A, Cannon St., London, E.C.

Aluminium Driving Pulleys Lengthen Life of Belts
See Pulleys Leaflet 7369
by THE BRITISH ALUMINIUM CO., LTD., 109, Queen Victoria St., London, E.C. 4.

See Advt. Page 36, Dec. 19.
Steam Hammers
Power Hammers
Steam and Friction Drop Stamps.
B. & S. Massey, Ltd., MANCHESTER.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

The National Foremen's Association of the Engineering and Allied Trades.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. A 330

All communications to— Head Offices—
H. W. Rhid, 81, High Holborn
General Secretary. London, W.C.1.

Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434 Offices of Engineering.

Correspondence Courses for

B.Sc., Inst.C.E., I.Mech.E., All Technical Exams. Special Courses and Single Subjects. Fees moderate.—For full particulars apply to Mr. Trevor W. Phillips, B.Sc. Honours (Eng.), A.M.I.C.E., &c., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 8071

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. Knowles, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., prepares candidates personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 8072

Land Surveying.—Courses

are now being held by Mr. D. S. Malden, suitable for those taking up work in England or abroad. New Courses just commencing.—Prospectus, apply 46, Central Hill, Upper Norwood, S.E. 19. C 46

Inst.C.E.&Inst.Mech.E. Exams

—A Practical Engineer, A.M.I.C.E., &c. (recently demobilised), has now resumed coaching for above by Correspondence, after 11 years' highly successful pre-war experience. Separate subjects may be taken. Excellent testimonials. Fees moderate.—C 90, Offices of Engineering.

A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—Pennington's, 264, Oxford Road, Manchester.

TENDERS.

Twenty Thousand Steel Gal-

vanised PETROL DRUMS, capacity 55 u.s. gallons, in good second-hand condition, are offered FOR SALE. Tenders are invited.—Addressed to MOTOR ORGANIZATIONS, Limited, 59, Shaftesbury Avenue, W. 1. C 470

AUCKLAND HARBOUR BOARD, NEW ZEALAND.

Tenders are Invited for the

SUPPLY and DELIVERY of TWELVE (12) Five-ton (and alternatively for Three-ton) SEMI-PORTAL, BALANCED-JIB, LEVEL-LUFFING ELECTRIC CRANES.

Specifications can be obtained at the Office of Board's Agents on payment of a deposit (returnable) of Two Guineas. Drawings can be seen only at the Office of the Board's Agents:
Messrs. W. & A. McArthur, Ltd.,
18-19, Silk Street,
Cripplegate, London, E.C. 2.
Tenders to reach Auckland by noon on Sept. 1st, 1920, addressed, The Chairman, Harbour Board, Auckland, New Zealand. C 444

LONDON COUNTY COUNCIL.

The Council invites

Tenders for the Removal and

Disposal of Ashes from Greenwich Generating Station, for a period of six and, alternatively, twelve calendar months, commencing 1st February, 1920. Particulars, Form of Tender, etc., may be obtained from the General Manager, London County Council Tramways, 23, Belvedere Road, S.E. 1. No Tender received at the County Hall after 12 noon on Tuesday, 13th January, 1920, will be considered.
The Council does not bind itself to accept the lowest or any Tender.
JAMES BIRD,
Clerk of the London County Council. C 499

PORT OF BRISTOL.

FERRO-CONCRETE WHARF, ROYAL EDWARD DOCK, AVONMOUTH.

The Docks Committee invite

Tenders for the Construction

of a DEEP WATER FERRO-CONCRETE WHARF, about 500 ft. long, at the Royal Edward Dock, Avonmouth.
On and after Monday, December 29th, 1919, a copy of the Form of Tender, General Conditions, Specification, Schedule of Prices, and a copy of the Contract Drawings can be obtained from the undersigned on production of a receipt shewing that a deposit of £5 has been paid to the Secretary of the Docks Committee, to whom all cheques must be made payable. The deposit of £5 will be returned herewith to all bona fide Tenderers.
Tenders must be enclosed in a sealed envelope endorsed "Tender for Ferro-Concrete Wharf," and addressed to the General Manager and Secretary of the Bristol Docks Committee Docks Office, 19, Queen Square, Bristol, and must be delivered to him, accompanied by the prescribed documents and drawings, before Ten a.m. on Monday, the 26th January, 1920.
THOMAS A. PEACH,
Engineer's Office, Engineer.
Avonmouth Docks.
19th December, 1919. C 461

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

No.		Fee for Specification.
1.	Gibs and Cotters	2/6
2.	Steel Nuts for Fishbolts... ...	2/6
3.	M.S. Bars, Sections, &c.	10/-
4.	Fencing Wire Strand	10/-
5.	Spark Arresters	5/-

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned marked "Tender for Gibs and Cotters," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 13th January, 1920.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE,
Secretary.
Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 23rd December, 1919. C 501

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD. (Plant and Machinery Section.)

For Sale, by Public Tender,

CHEMICAL PLANT.

Continuous Plant for the Production and Rectification of Sulphuric Ether, each producing 30 tons of rectified ether at 65° per 24 hours.
Six Ether Equipments of 21,000 kgs. and various Accessories. The apparatus installed in two separate structures, forming two groups of three equipments each. Production of one group 130,000 kgs.
The above plant is in first-class condition, and is lying in cases unpacked at H.M. Factory, Henbury.
Tenders close January 6, 1920.
WOOD LEAD-LINED TANKS.
Sizes varying between 3 ft. 11 in. by 3 ft. 2 in. by 3 ft. 3 in. and 10 ft. 6 in. by 10 ft. 6 in. by 4 ft.
Lying at H.M. Factory, Litherland. Ref. G.88.
Tenders close January 6, 1920, at 10 a.m.
MISCELLANEOUS PLANT.
Lying at Farina Mills (Albion Hill), Bradford, Lincoln.
Potato Washing Machines, Hydro Extractors, Friction Sack Hoist, Tanks of various sizes, Offal Press, Potato Receiving Reel, Fibre Extractors, Oak Cleansing Vats, Sirocco Fans, Potato Breakers, Three-tier Steam Jacketted Worms, Potato Grinders, Disc Feeders, Double Dryer Conveyor, Steel Hand Packing Cylinders, Pipes, Shafting, Pulleys, Belting and other Accessories.
Tenders close 10 a.m., January 3rd. Ref. G 1735.
WOOD DISTILLATION PLANT.
From H.M. Factory, Carmarthen, stored at H.M. Factory, Mid-Lavant, Ludlow, Longparish and Bideford. Plant comprises the following:—
Sets of Retort Platework, complete with doors and frames; Retort Condensers, Tar Separators, Roots Blowers, Traversers, Smoke Consuming Apparatus, Winches, Copper Vapour Pipes, Corwood Cars. Copper Seals for Tar Separators, and other Accessories.
Tenders close January 6th, 1920. Ref. G. 408.
Full particulars of the above, together with Tender Forms and permit to view can be obtained on application to the CONTROLLER, D.B.I.e., Charing Cross Embankment Buildings, W.C.
Note.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 3s., post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. C 268

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4350, Offices of Engineering.

WORCESTER EDUCATION COMMITTEE.

VICTORIA INSTITUTE SCIENCE AND TECHNICAL SCHOOL.

Head Master: J. NEWTON FRIEND, D.Sc.

Applications are Invited for

the POST of ASSISTANT LECTURER IN ENGINEERING. Salary £250–£25–£300. Further particulars may be obtained from the HEAD MASTER. Applications should reach me not later than January 3rd.
THOS. DUCKWORTH,
Secretary for Higher Education.
Victoria Institute,
Worcester. C 334

COUNTY BOROUGH OF WEST HAM.

MUNICIPAL TECHNICAL INSTITUTE, Romford Road, Stratford, E. 15.

Applications are Invited for

the following POSTS:—
CHIEF LECTURER in Electrical Engineering. Salary (including war bonus) £350 per annum, rising by annual increments of £10 to a maximum of £400 per annum.
ASSISTANT LECTURER in Civil and Mechanical Engineering. Salary (including war bonus) £300 per annum.
ASSISTANT LECTURER in Physics. Salary (including war bonus) £300 per annum.
Application forms and further particulars may be obtained from the PRINCIPAL on receipt of stamped addressed foolscap envelope.
Applications, with copies of recent testimonials, should be sent to the PRINCIPAL, Municipal Technical Institute, Romford Road, Stratford, E. 15, not later than 12th January, 1920.
GEORGE E. HILLBARY,
Town Clerk.
Education Department,
95, The Grove, E. 15.
10th December, 1919. C 312

CITY OF BRADFORD EDUCATION COMMITTEE.

TECHNICAL COLLEGE.

ASSISTANT LECTURER IN PHYSICS.
ASSISTANT LECTURER IN ELECTRICAL ENGINEERING.
ASSISTANT LECTURER IN TEXTILE MECHANICS.

Applications are Desired for

the above APPOINTMENTS. Salary Scale £150 to £350, with an additional bonus of £78. Initial Salary governed by qualifications of successful candidates. Further particulars may be obtained from the PRINCIPAL of the College.
BY ORDER.
12th December, 1919. C 344

LONDON COUNTY COUNCIL.

There is a Vacancy for a

VISITING TEACHER of ELECTRICAL ENGINEERING on three evenings a week at the L.C.C. Hackney Institute, Dalston Lane, E. 8. The rate of pay will be 15s. an attendance. Practical experience in works is essential and experience in teaching will be a recommendation. Preference will be given to those persons who have served or attempted to serve with the Forces of the Crown.
Application forms may be obtained from the EDUCATION OFFICER (T. 1), Education Offices, Victoria Embankment, W.C. 2 (stamped addressed foolscap envelope necessary). Form must be returned by 11 a.m. on 12th January, 1920. Canvassing disqualifies.
JAMES BIRD,
Clerk of the London County Council. C 498

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. Schofield, M.B.E., B.Sc. Hons. (Lond.), A.R.C.Sc. (Lond.), Assoc.M.Inst.C.E., Principal.

Wanted for the Commence-

ment of the Lent Term:—
(a) A SENIOR LECTURER in AUTOMOBILE ENGINEERING. Salary £350 per annum, rising by annual increments of £25 to £450.
(b) A JUNIOR LECTURER in AUTOMOBILE ENGINEERING. Salary £250 per annum, rising by annual increments of £25 to £350.
It is essential that applicants possess a University Degree or its equivalent. Further details of the appointments and Forms of Application may be obtained from the Principal at the College, to whom applications must be returned not later than the 31st December, 1919. C 336
W. A. BROCKINGTON,
Director of Education.

The Royal Technical College,

Glasgow, Department of Mechanical Engineering.—Several JUNIOR ASSISTANTS are REQUIRED, mainly to give instruction in drawing and in the laboratories; duties to commence at an early date; Salaries from £250 per annum, according to training and experience.—Applications should be addressed to the PROFESSOR OF MECHANICAL ENGINEERING, The Royal Technical College, Glasgow. C 485

Estimator Wanted at Once

for Engineer's London Office. Structural and some knowledge of Mechanical Work. Permanent position for suitable man.—Address, C 423, Offices of Engineering.

Wanted, Manager for Ship-

Building, Ship Repair and General Engineering Works in Calcutta. Candidate must be a smart and capable man, able to estimate costs quickly. An adequate salary and commission will be paid to the right man.—Address, stating age and qualifications to Z. K. 897, care of Deacon's, Leadenhall Street, London, E.C. 3. C 261

Works or Production Manager

WANTED, for large Automobile Factory in the North of England employing over 800 hands. Applicants must be energetic men of proved administrative ability, with a wide practical experience in modern workshop methods of mass production on a large scale, of strong personality, and able to handle judiciously all classes of labour, and systematically organize to obtain maximum results. Only men of the highest ability will be considered—no others need apply.
Address, in confidence, giving fullest particulars of experience, with copies of recent references, age and salary required, to C 366, Offices of Engineering.

Works Manager Required to

take sole control of manufacturing side of large Brick Company. Applicants must have first class experience in the maintenance of modern high-class steam plants, with up-to-date knowledge of economical and efficient working.—Apply, giving experience and copies of recent testimonials, stating salary expected, to BOX 481, Willing's, 125, Strand, London, W.C. 2. C 323

Scientific Works Management.

—ENGINEER WANTED by large electrical manufacturing concern to take full charge of their power press department, engaged on very accurate work. Applicants must have had a thoroughly practical and technical engineering training and be used to up-to-date methods of quick production of repetition work. Applications (in confidence) should state age, experience, positions held previously and salary required.—Address, C 432, Offices of Engineering.

Wanted, Assistant Works

MANAGER to take entire charge of Drop Stamping Department specializing on Motor Car Parts. Must have sound knowledge of Die making and heat treatment of Alloy Steels. Good opportunity for first-class man.—Address, C 486, Offices of Engineering.

Wanted, First-class Colliery

MECHANICAL ENGINEER with electrical experience, for Colliery in India. Three years' agreement on Rs. 500, 550, 600.—Write, S. X., c/o J. W. Vickers & Co., Ltd., 5, Nicholas Lane, E.C. 4. C 493

A Leading Firm of Ship-

Repairers in France REQUIRE services of Young Engineer with sea experience and able to talk French, as ASSISTANT to outside Manager. The situation offers prospects for a suitable man.—Address, stating age, experience and salary required, C 491, Offices of Engineering.

Aerial Ropeway Engineer

WANTED, to take full charge of London Office, capable of estimating cost, surveying and taking full charge of business. Apply, stating experience, and salary expected, to BOX 564, Robertson & Scott, Advertising Agents, Edinburgh. C 264

Experienced Catalogue and

Publicity Engineer WANTED for Department requiring rapid output of Catalogues and similar work.—Address, experience, age and salary required to AGRICULTURAL & GENERAL ENGINEERS, Limited (Temporary Offices), 80, Pall Mall, S.W. C 189

Assistant Engineer

REQUIRED for the Re-alignment of the Secondee Kumasi Section of the Gold Coast Government Railway, for one tour of twelve month's service, with possible extension. Salary £400 a year and a War Bonus of £120 a year. Field allowance at the rate of £90 a year. First-class passages. Liberal leave in England on full salary. Candidates, aged 29–45, who must have had experience as Assistant Civil Engineers on Railway Location and Construction, should apply at once, in writing, giving brief details of experience and age, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/G.C. 9402. C 406

Assistant Engineers

REQUIRED for the Nigerian Government Railways for two tours each of 12 months' service with possible permanency. Salary £350–£10–£400 and a war bonus of £120 a year. Free single quarters and first class passages. Liberal leave in England on full salary. Candidates, aged 22–35, who have had experience as Assistant Civil Engineers on Railway Construction, should apply at once, by letter, giving brief details of experience and age, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Nig. 9459. C 479

Assistant Engineers

REQUIRED for the Public Works Department of the Federated Malay States for three years' service, with prospect of permanency. Salary £360—£15—£480, duty allowance of £75 a year, and a war bonus of 30 per cent. of salary only. First class passages. Prospects of promotion, if remaining in the service, to higher posts with salaries ranging between £480 and £1200 a year.
Candidates, 23–35 years of age, preferably single, who have received a good theoretical training, preferably at a University or Engineering College recognised by the Institution of Civil Engineers, or have completed their articles with Civil Engineers of Standing, and passed the A.M.Inst.C.E. Examinations, should apply at once (by letter), giving brief details of age and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W. 1, quoting M/F.M.S. 8923. C 484

BOROUGH POLYTECHNIC INSTITUTE. Borough Road, London, S.E. 1.

CHIEF ASSISTANT IN ENGINEERING DEPARTMENT.

The Governors REQUIRE at once a

Chief Assistant in the Engi-

neering Department, whose duties would be mainly connected with the work of the Evening Classes. Candidates should possess a Degree or equivalent qualification, and should have had works and Technical College training and some teaching experience. The commencing salary will be £400 per annum (inclusive of bonus), rising by yearly increments of £10 to £450. Particulars and form of application may be obtained by sending stamped addressed foolscap envelope to
C. T. MILLIS,
Principal. C 337

CORPORATION OF CALCUTTA.

WANTED.

Applications are Invited for

the POST of EXECUTIVE ENGINEER, Drainage, Calcutta. The salary of the appointment, inclusive of allowances, is Rs. 1300, rising to Rs. 1500 per month by annual increments of Rs. 50. The person appointed will be required to keep a motor car. The cost of a motor car will, if desired, be advanced by the Corporation and recovered in monthly instalments spread over three years.
The appointment is subject to the Provident Fund. Leave and other service rules of the Corporation, and may be terminated at any time by six months' notice on either side. The Provident Fund contribution is 6¼ per cent. of the monthly salary, and an equivalent amount is contributed by the Corporation, and the fund accumulates at compound interest. The selected candidate will be under the direction of the Chief Engineer and be required to devote his whole time to the duties of his office and will not be allowed to take up any private work. He must reside in Calcutta. He will be liable to removal during the term of his office for misconduct or neglect of, or incapacity for his duties. He will be required to submit to a medical examination before joining his appointment. The Corporation will pay his passage (1st class) from London to Calcutta, but he must refund the amount so paid if he gives notice within two years from the date of taking up his appointment. He will be required to take up his appointment about the 1st April, 1920, and will receive half-pay for the period occupied by the journey.
(b) Preference will be given to candidates who are Members or Associate Members of the Institute of Civil Engineers, or Graduates in Engineering of a University, and have had experience in the design, construction and maintenance of sewerage projects for large cities, including pipe and masonry sewers, pumping stations, sewage treatment and disposal, as well as road and general construction works.
(c) Candidates are to state their age and experience.
(d) Applications will be received in the United Kingdom up to the 15th January, 1920, by W. C. Easton, Esq., B.Sc., M.I.C.E., West Street, Glasgow, from whom any other information concerning the conditions of service, etc., may be obtained, or in Calcutta up to the 15th January, 1920, by the Secretary to the Calcutta Corporation, Central Municipal Office.
J. C. Mukerjha,
Secretary to the Corporation.
17th November, 1919. C 326

INFLUENCE LINES APPLIED TO ARCH DESIGN.

By G. R. MAGNEL, I.C.C. (Ghent).

As it is being more and more recognised, both in this country and abroad, that an immense benefit would result from a closer co-operation of engineers and scientists of all countries, the writer, who has been resident in England for some years and has much appreciated the value of British engineering methods, may be justified in dealing here, for the benefit of the English speaking reader, with a subject that is neglected and even wrongly treated in many English text-books.

In dealing with arch design most authors give a method of finding the stresses when the loads are permanent, but the question of rolling loads is hardly ever more than mentioned, and if mentioned at all it is generally said that these loads should be considered in three or four different positions and in each case be dealt with as permanent loads. This is rather a long and inaccurate method, and influence lines should always be used in the case of live loads. These lines are rarely used in this country, and the very few authors dealing with them give a method for plotting them which will discourage most practical engineers as being too long and complicated.

Besides this, some very serious mistakes have been made. One author, whose books have a rather wide circulation, works out a numerical example and finds as haunch moment — 268 ft.-t., whereas it should be about + 321 ft.-t., which anyone familiar with arches might know without calculation as explained hereafter. What is still more surprising is that this wrong result is "closely checked" (?) in the same book by the influence line method.

The aim of the present article is to give a clear idea of how an arch should be designed when loaded with rolling loads, without spending on it more than a short time. This will be done by a method that might be called "mechanical," inasmuch as its application does not make any appeal to the engineer's memory and can even be carried out by an intelligent draughtsman under an engineer's guidance.

The following preliminary remarks may prove useful :—

The influence line* for the right hand haunch moment is generally as shown on Fig. 1. A load P acting on the arch ring creates at B a bending moment equal to P times the corresponding ordinate m_B of the influence line, so that this line shows at a glance how the bending moment at B varies when the load P travels over the arch.

If a uniformly distributed load p covers part of the arch, the bending moment at B is equal to p times the corresponding area "a" of the influence line. Again, this line shows at a glance which partial uniform loading produces the maximum bending moment at B: the positive maximum occurs when the load p covers the arch from A to D and the negative maximum when the load covers the arch from D to B. It is also at once clear that the B moment is very small when the arch is completely covered with the uniform load p, as in this case the B moment is p times the difference between the positive and negative areas of the influence line; this difference is often only a small percentage of each of its terms.

This brings the writer to a very important point. The moment at B due to a uniform load covering the whole arch ring cannot be deduced accurately from an influence line, unless this curve be drawn with the utmost accuracy, as indeed an error as small as 2 per cent. in its ordinates will make as much as 20 per cent. and possibly more in the difference between the positive and negative areas. This shows that in dealing with arches the loads should generally be divided in two distinct classes: (1) the rolling loads, either uniform or concentrated; they should always be dealt with by influence lines. (2) The permanent loads, composed of the deadweight of the ring and the filling above it; these loads are generally, if not uniformly, at least symmetrically distributed, so that it is possible that the influence line method does not give sufficient accuracy if applied to them. This is, for instance, the case with reinforced concrete road bridges, with rather a large amount of filling, and relatively light rolling loads, in which case the moments due to permanent loads are just as important as those due to rolling loads: and the influence line method should not be used for the permanent loads. On the contrary, in the case of a railway bridge, made of steel arches without filling, and where the rolling loads are very important, the moments due to dead load may sometimes be

Fig. 1.

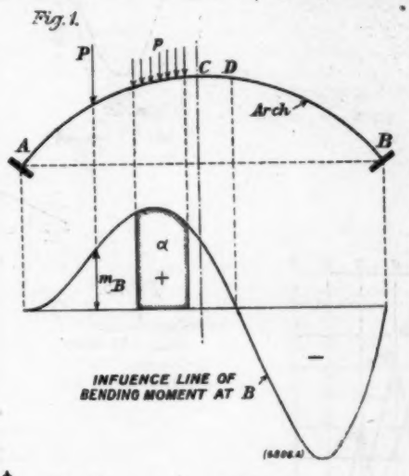
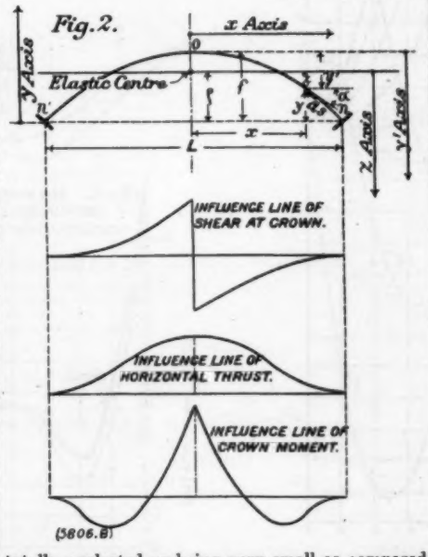


Fig. 2.



totally neglected as being very small as compared with live load moments. In such a case the influence lines alone will give all the data required.

The writer proposes now to explain the method of plotting influence lines. Although a few formulæ will be used, these may be totally forgotten by one who applies the method and are only given here for the purpose of showing the foundations of the further calculations.

The equations of the influence lines for the shear force p_0, the horizontal thrust q_0, and the bending moment m_0 at the crown are* :—

$$p_0 = \frac{\int_x^{L+2} \frac{x^2}{I}\,ds - x\int_x^{L+2} \frac{x}{I}\,ds}{\int_{-L+2}^{+L+2} \frac{x^2}{I}\,ds}$$

$$q_0 = \frac{\int_x^{L+2} \frac{zx}{I}\,ds - x\int_x^{L+2} \frac{z}{I}\,ds}{\int_{-L+2}^{+L+2} \frac{z^2}{I}\,ds + \int_{-L+2}^{+L+2} \frac{\cos^2\alpha}{\Omega}\,ds}$$

$$m_0 = -(f-\rho)q_0 + \frac{\int_x^{L+2} \frac{x}{I}\,ds - x\int_x^{L+2} \frac{1}{I}\,ds}{\int_{-L+2}^{+L+2} \frac{1}{I}\,ds}$$

$$\rho = \frac{\int_{-L+2}^{+L+2} \frac{y}{I}\,ds}{\int_{-L+2}^{+L+2} \frac{1}{I}\,ds} \quad \text{with } z = \rho - y$$

The meaning of the letters used is explained by Fig. 2. The above formulæ are only correct for values of x between o and $+L \div 2$, and consequently they will only give one-half of each of the influence lines, but as the latter have all a certain degree of symmetry, as suggested in Fig. 2, no trouble arises through this.

In the above formulæ, as in the following calculations, the signs given to the shear forces and bending moments are such that the shear force at the left of a simply supported beam with downward loads applied to it is positive, as well as the moments in the same beam. Let it finally be noted that the second term of the denominator of q_0 arises from the consideration of the rib shortening due to the thrust. This term may be neglected as being unimportant in the case of high arches, but must unquestionably be taken in account for flat ones.

In any numerical application the above formulæ must be transformed into actual figures, and it is the way in which this is done that makes a method easy or difficult.

On careful examination it will be seen that two very different kinds of integrals have to be calculated :—(1) Those with two constant limits $+L \div 2$ and $-L \div 2$; and (2) those with the variable x as one limit, the other one being the constant quantity $+L \div 2$. For the first integrals one value only need be found, whereas for the second one a value must be found for every value of x.

The first integrals are of the following general type :—

$$V = \int_{-L+2}^{+L+2} Y\,dx$$

The value of V is merely the area of a curve, and is most conveniently calculated by a table similar to Table A, page 845, the letters being, of course, replaced by figures. The right-hand half-span is divided into n equal parts and the points marked n, n-1, . . . 2, 1, 0 (n corresponding to the haunch and o to the crown). The values of Y at these points are noted in the second column of Table A, the two extreme ones being written down as $2 \times Y \div 2$. By adding the values written the one under the other in the second column, a value

$$S = \frac{Y_n}{2} + Y_{n-1} + \ldots + Y_1 + \frac{Y_0}{2}$$

is found. The integral V is then equal to :—

$$V = \frac{L}{n} S$$

The second integrals are of the general type :—

$$W = \int_x^{L+2} Y\,dx$$

Their values for each value of x is most conveniently found by Table B, where again figures must take the place of letters; these are only used here to explain the plan of passing from one column to another by a series of simple additions; the second column contains the ordinates at the points n, n-1, . . . 2, 1, 0; the third column marked 2 contains the sums of the ordinates two by two; the fourth column marked U contains the successive sums of the figures of the third columns. The

* For a definition of influence lines, see the writer's two previous articles: "Design of Flat Arches with Fixed Ends," ENGINEERING, April 27, 1917, page 391, and "Stresses in Rectangular Frames," *Concrete and Constructional Engineering*, October, 1917, and November, 1917.

* See ENGINEERING, April 27, 1917, page 391, "Design of Flat Arches with Fixed Ends."

values of U so obtained are such that at any point x:—

$$W = \frac{L}{4n} U$$

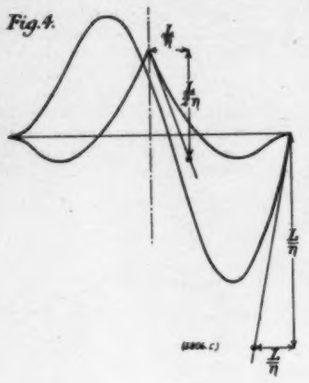
It is now easy to explain the method of finding the influence lines for p_0, q_0 and m_0. This is done by means of Tables C and D. Table C gives the values of the different integrals required by direct application of the typical Tables A and B; this is shown on the top line of Table C as headings. Table D combines these integrals as required by the formulæ giving p_0, q_0 and m_0.

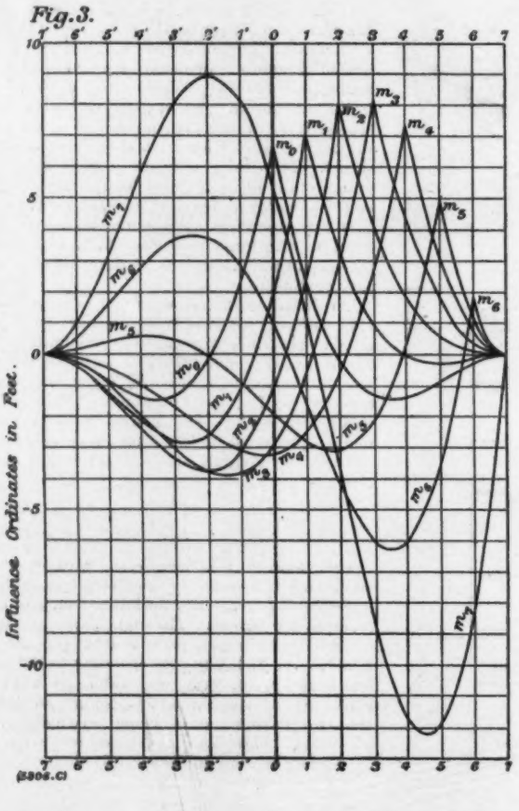
After what has been said very little explanation is required, as the tables C and D give by themselves all information for their filling in. The figures shown in the tables are for one example that has been worked out in order to help the reader who may feel inclined to apply the method. The example chosen is an arch of 150 ft. span, 15 ft. rise, the centre line of which is circular. The arch is in ferro-concrete, the thicknesses at the crown and the haunches being respectively 2 ft. and 3 ft. and the reinforcement are kept constant throughout, equal to 2 per cent. of the total crown area, half of it being placed at 2 in. from the intrados and half at 2 in. from the extrados. In this particular case the half span has been divided into seven equal parts, numbered 7 to 0, 7 being the right hand haunch and 0 the crown; this is quite enough for all practical purposes; 5 equal parts to the half span will generally do for estimating purposes.

Columns 1, 2, 3 and 4 of Table C give merely the geometrical characteristics of the ring and the real calculations start with column 5; the slide rule will be found quite accurate enough in all these calculations.

The only explanation Table C might need further is the way of calculating column 9 (and also 12 and 20). To get the figures of column 9 multiply the corresponding ones of column 5 respectively by 7, 6, . . . 2, 1 and 0; this is the meaning of the heading n, n-1, . . . × col. 5.

Table C being filled in it will be noted that for convenience Table D has to be filled in line after line and not column after column as Table C. All the elements required for Table D are found in Table C; for instance, line 2 of Table D is identical with column 14 of Table C; line 3 of Table D is obtained by multiplying the figures of column 11 of Table C respectively by 7, 6, . . . 2, 1 and 0.





Lines 5, 9 and 15 of Table D give the final influence ordinates p_0, q_0 and m_0; the latter influence lines can then easily be plotted, as eight equidistant ordinates of each of them are known in the right half-span.

The next important thing, however, is to draw the moment influence lines for other points than the crown, but this is a matter of mere statics as the statical indetermination of the problem is solved once the three influence lines for the shear, thrust and moment at the crown are known. If, for instance, the moment influence line for point x_K is required, its ordinate m_K at any point x is given by:—

$$m_x = m_0 + p_0 z + q_0 y' - x_2 + z$$

for the values of x between 0 and x_K, and

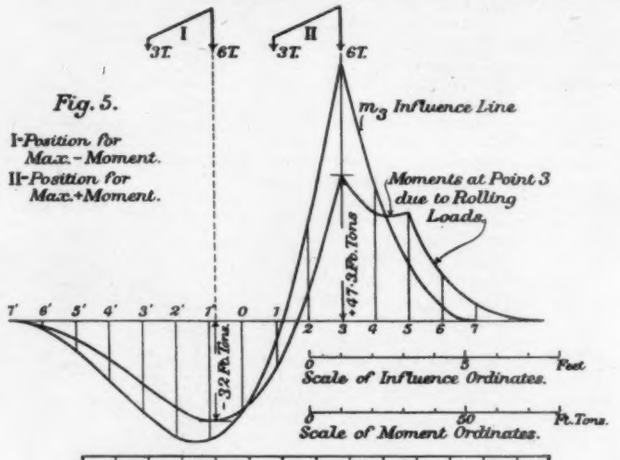
$$m_x = m_0 + p_0 z + q_0 y'$$

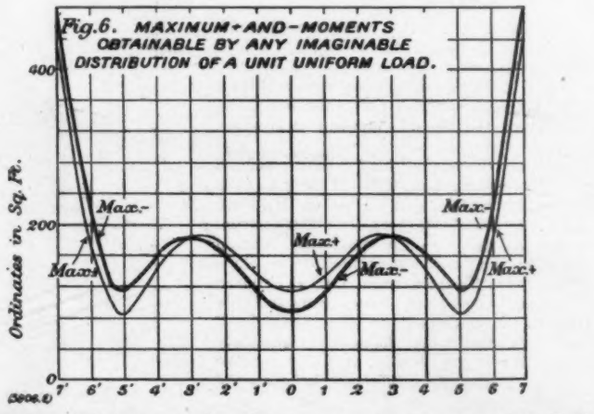
for the other values of x.

The last two formulæ have been applied to the example chosen above and the resultant moment influence lines for points 7, 6, 5, 4, 3, 2, 1 and 0 shown in Fig. 3. Generally it will not be necessary to plot as many influence lines as shown on Fig. 3; it has only been done here in order to show how the lines change gradually in shape so as to alter from the crown line to the haunch line. For estimating purposes it would be enough to draw these two extreme lines.

A very useful check on the above calculations consists in the fact that, as suggested on Fig. 4, the tangents at point 0 to the influence line of the crown moment have always the same slope determined by setting out the values of $L \div n$ and $L \div 2n$ respectively as abscissa and ordinate, each being, of course, measured to its own scale; a similar construction gives the tangent at 7 to the moment influence line for the haunch. Further all the moment influence lines have to pass through points 7 and 7′ and to be tangent at these points to the reference line (except 7 at point 7).*

Once the lines shown on Fig. 3 are plotted it is easy to find the maximum moment at any point of the arch due to any set of rolling loads, say, for instance at point 3. The influence line at this point is copied in Fig. 5; the rolling loads considered consist of a set of two loads of 3 tons and 6 tons respectively at a distance of 21 ft. 6 in. the one from the other. The moment at point 3 for any position of the rolling loads is the sum of the products of each load by the corresponding influence ordinate; plotting this moment as ordinate at, say, the point occupied by the 6-ton load, a new curve is found, showing the variation of the moment at 3, when the set of rolling loads travels over the arch (Fig. 5). The maximum positive moment occurs for the position II of the loads and is equal to 47·3 ft.-t., whereas the maximum negative moment occurs when the loads occupy the position I and is equal to − 32 ft.-t.





If now uniformly distributed rolling loads are considered, the maximum positive moment at any

* See Engineering, April 27, 1917, page 391, "Design of Flat Arches with Fixed Ends."

TABLE A.

Number of Section.	Ordinate.
n	$2 \times y_n + 2$
$n-1$	y_{n-1}
$n-2$	y_{n-2}
2	y_2
1	y_1
0	$2 \times y_0 + 2$

$S =$

TABLE B.

Number of Section.	Ordinate.	Sum Σ of Ordinates 2 by 2.	Values of U.
n	y_n		$U_n = 0$
$n-1$	y_{n-1}	$\Sigma_{n-1} = y_n + y_{n-1}$	$U_{n-1} = U_n + \Sigma_{n-1}$
$n-2$	y_{n-2}	$\Sigma_{n-2} = y_{n-1} + y_{n-2}$	$U_{n-2} = U_{n-1} + \Sigma_{n-2}$
2	y_2		
1	y_1	$\Sigma_1 = y_2 + y_1$	$U_1 = U_2 + \Sigma_1$
0	y_0	$\Sigma_0 = y_1 + y_0$	$U_0 = U_1 + \Sigma_0$

TABLE C.

	Length Unit = Foot.				As Table B.			As Table A.	As Table B.			As Table B.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Number of Section.	Ord. y.	Cos α	I	$\frac{1}{I \cos \alpha}$	Σ	U_7	Col. 2 × Col. 5.	$n, n-1, \ldots$ × Col. 5.	Σ	U_{11}	$n, n-1, \ldots$ × Col. 9.	Σ	U_{14}
Haunch	$n = 7$	0·0	0·923	3·32	0·326		0·0	0·0	2·282		0·0	15·974		0·0
	6	4·099	0·944	2·56	0·414	0·740	0·740	1·697	2·484	4·766	4·766	14·904	30·878	30·878
	5	7·497	0·961	2·05	0·507	0·921	1·661	3·800	2·535	5·019	9·785	12·675	27·579	58·457
	4	10·232	0·975	1·65	0·622	1·129	2·790	6·365	2·488	5·023	14·808	9·952	22·627	81·084
	3	12·333	0·986	1·43	0·716	1·332	4·122	8·750	2·130	4·618	19·426	6·390	16·342	97·426
	2	13·819	0·994	1·30	0·773	1·483	5·605	10·690	1·546	3·676	23·102	3·092	9·482	106·908
	1	14·705	0·998	1·17	0·856	1·629	7·234	12·560	0·856	2·402	25·504	0·856	3·948	110·856
Crown	0	15·000	1·000	1·08	0·926	1·782	K = 9·016	2 × 6·945	0·0	0·856	26·360	0·0	0·856	l = 111,712
								S_8 = 50·827						

TABLE C—(*continued*).

	—		As Table B.			As Table B.			As Table A.		As Table A.	
	15	16	17	18	19	20	21	22	23	24	25	26
		$z = \rho - y$.	Col. 5 × Col. 16.	Σ	U_{19}	$n, n-1, \ldots$ × Col. 17.	Σ	U_{22}	Col. 16 × Col. 17.	Ω	$\frac{\text{Cos } \alpha}{\Omega}$	
Calculate $\rho = \frac{2 S_8}{M} = \frac{2 \times 50·827}{9·016} = 11·275$		+11·275	+ 3·680		0·0	+25·760		0·0	2×20·75	3·60	2×0·13	Calculate $r = s_{23} + s_{25} = 74·48$.
		+ 7·176	+ 2·973	+ 6·653	6·653	+17·838	+43·598	43·598	21·33	3·46	0·27	
		+ 3·778	+ 1·914	+ 4·887	11·540	+ 9·570	+27·408	71·006	7·23	3·81	0·29	
		+ 1·043	+ 0·649	+ 2·563	14·103	+ 2·596	+12·166	83·172	0·68	3·17	0·31	
		− 1·058	− 0·751	− 0·102	14·001	− 2·253	+ 0·343	83·515	0·79	3·03	0·32	
		− 2·544	− 1·970	− 2·721	11·280	− 3·940	− 6·193	77·322	5·01	2·89	0·34	
		− 3·430	− 2·935	− 4·905	6·375	− 2·935	− 6·875	70·447	10·06	2·74	0·36	
		− 3·725	− 3·448	− 6·383	0·0	0·0	− 2·935	67·512	2× 6·42	2·60	2×0·19	
								S_{23} = 72·27		S_{25} = 2·21		

TABLE D.

		Haunch.							Crown.
1	Mark of point	7	6	5	4	3	2	1	0
2	U_{14}	0	30·878	58·457	81·084	97·426	106·908	110·856	111·712
3	$n, n-1, \ldots \times U_{11}$ ..	0	28·596	48·925	59·232	58·278	46·204	25·504	0
4	Line 2–Line 3	0	2·282	9·532	21·852	39·148	60·704	85·352	111·712
5	Line 4 ÷ 2 I = p_0	0	0·0102	0·0427	0·0977	0·175	0·272	0·382	0·500
6	U_{22}	0	43·598	71·006	83·172	83·515	77·322	70·447	67·512
7	$n, n-1, \ldots \times U_{19}$ ..	0	39·918	57·700	56·412	42·003	22·560	6·375	0
8	Line 6–Line 7	0	3·680	13·306	26·760	41·512	54·762	64·072	67·512
9	Line 8 × L ÷ 8 $n r$ = q_0 ..	0	0·1323	0·478	0·962	1·494	1·970	2·303	2·428
10	U_{11}	0	4·766	9·785	14·809	19·426	23·102	25·504	26·360
11	$n, n-1, \ldots \times U_7$ ..	0	4·440	8·305	11·160	12·366	11·210	7·234	0
12	Line 10–Line 11	0	0·326	1·480	3·648	7·060	11·892	18·270	26·360
13	Line 12 × L ÷ 4 n K ..	0	0·194	0·880	2·170	4·200	7·075	10·870	15·670
14	$(f - \rho) \times$ Line 9	0	0·489	1·780	3·580	5·570	7·330	8·580	9·050
15	Line 13–Line 14 = m_0 ..	0	− 0·295	− 0·900	− 1·410	− 1·370	− 0·255	+ 2·290	+ 6·620

point, say 3, occurs when the part of the arch corresponding to the positive part of the influence line is covered by the load; this maximum is equal to the magnitude p of the load per unit length multiplied by the positive area of the influence line. If this positive area is taken as ordinate at point 3, and if a similar ordinate is plotted at every point, a curve is obtained as one of the two curves of Fig. 6, the other one being for the negative moments.

It is useful to draw attention to the fact that the positive area of an influence line as taken for ordinate in Fig. 6, may be composed of two parts; this is, for instance, the case for point 5, Fig. 3 showing that the influence line has two areas above the reference line and one under it; the moment due to uniform loading at point 5 is maximum positive when the loads cover the arch from 7′ to about 2′ and simultaneously from 7 to about 4; the moment is maximum negative when the load covers the arch from about 2′ to about 4; these are the moments taken as ordinates in Fig. 6. The curves give at any point the maximum positive and negative moment possible to be obtained by a unit uniform load covering the arch in any imaginable position. The ordinates between the two curves of Fig. 6 represent, of course, the moments in the ring when the unit uniform load completely covers the arch. As explained in the beginning of the present article these partial ordinates are very small as compared with the full curve ordinates and a small error in the full curve ordinates may affect considerably the small partial ordinates. That is why it is advisable not to use the curves of Fig. 6 to get the moments due to a load completely covering the ring; these moments should be found by other methods as explained in all text-books.

The curves of Fig. 6 show, for instance, that the maximum positive fixing moment at the right hand haunch due to a uniform load of p tons per foot run is equal to 440 p ft.-t.; this maximum occurs when p covers the arch between point 7′ and a point situated between 1 and 2, as shown by the influence line m_7 of Fig. 3. When the other part of the arch is covered, the moment at 7 is maximum negative and equal to − 474 p ft.-t.

If the arch is loaded first from 7′ to 0 and then from 0 to 7, the above moments become respectively 403 p ft.-t. and − 436 ft.-t.; consequently if, for instance, a uniform load p = 1.3 t/ft. covers the left half of the arch and simultaneously a load p = 2·2 t./ft. covers the right half of the arch, the resultant moment at 7 will be:—

$$403 \times 1{\cdot}3 - 436 \times 2{\cdot}2 = - 434 \text{ ft. t.}$$

The corresponding moment at 7′ would be:—

$$403 \times 2{\cdot}2 - 436 \times 1{\cdot}3 = + 321 \text{ ft. t.}$$

These are the figures for which the author of the book mentioned in the preliminary remarks finds − 410 and − 268; this is obviously wrong as "a priori" these moments cannot be of the same sign (see shape of influence line).

Having filled in Tables C and D and dealt with rolling loads, either concentrated or uniform, as explained, no further calculations are required to find the effect of a rise t in temperature; this produces a thrust equal to:—

$$Q_t = \frac{E c t n}{r}$$

where C = coefficient of linear expansion, E = modulus of elasticity, n = number of divisions of half span, r = figure calculated in column 26 of Table C. The corresponding moment at any point of the arch is:—

$$m_t = Q_t z.$$

It is worth noting that the two last formulæ take into account the rib shortening of the arch due to the thrust (this affects the denominator r). Most authors consider the arch as loaded by three different "loadings," being: (1) the actual vertical forces acting on it; (2) the temperature effect; and (3) the shortening of the rib due to the thrust. This is illogical as the last item exists only in combination with each of the two first named. This shows that calculating item (3) by taking as thrust the maximum due to (1) and (2) combined and then combining (3) with (1) or (2) separately is obviously wrong. The way explained in the present article

is just as simple, if not simpler, and much more accurate and logical.

The writer must apologise for not going further into details; many points would be worth mentioning as the effect of the distribution through the filling and the arch itself of so-called point loads and the corresponding decrease in bending moments; the alteration to the influence lines when the rolling loads act on the arch through the medium of transverse beams running from ring to ring, &c. Dealing with all these points would run into too great length, however, and as it stands, the writer hopes that the present article may prove useful.

LITERATURE.

Reports on the Progress of Applied Chemistry. Issued by the Society of Chemical Industry. Volume III, 1918. London: The Society of Chemical Industry.

The sections on Ceramics, Building Materials and Fermentation were not ready in time for inclusion in this third report. On the other hand, sections on Agricultural Chemistry, by Dr. E. J. Russell, F.R.S., and on Foods, by Dr. H. W. Bywaters, have been added to the volume, and as the authors do not confine themselves to the year 1918, the sections contain much interesting matter. A few notes may be acceptable. The food production of this country, Dr. Russell reports, one-half of the total need before the war, was at low ebb in 1916, but improved in 1917 and surpassed in 1918 that of any previous year. In the manufacture of fertilisers nitre cake has replaced sulphuric acid; one of the troubles of the innovation is that the product tends to set to a hard cake. With respect to basic phosphate slag, which became very important during the war, it is noteworthy that the open-hearth slag contains less phosphate than the Bessemer converter slag, and for the analyst the addition of fluorspar to the slag (to increase its fusibility) is unfortunate in so far as it interferes with the solubility of the phosphate in citric acid, and is thus apt to lower the analytical estimates of the slag as fertiliser. Attempts have hence been made to enrich the slag either by the addition of mineral phosphates or by fractionation (Hoersch, Queling). As regards food and war bread, Dr. Bywaters states that the number of potato-drying works had, in Germany, increased from 6 to 841 by 1916, while over here, until recently, undesiccated potatoes were added to the bread. Milk powders are produced by a quick drying process; a thin film of milk is rapidly heated for a short time so that the protein does not coagulate and will redissolve in water. The Merrell-Soule Company effects this by running the milk into a heated centrifugal drum in which the milk rises in a spiral to be sprayed into hot air; the vapour is condensed and produces the vacuum in the centrifugal apparatus. All these drying processes are suspected of causing a loss of vitamines, the mysterious agents, at least three of which are said to be necessary in the food to make growth of the animal possible. Considering that we still know very little about milk, even cow's milk, and do not really understand why butter turns rancid, as Dr. Bywaters points out, the vitamine problem may yet puzzle further generations; vitamine research practically began in 1912.

We may mention a few facts from other sections. Reference to the H. Lane process of producing finely-divided nickel for catalysis looks rather out of place in Mr. J. W. Hinchley's section on Plant and Fuel; but the device, a pan heated by a ring burner, really forms part of plant. Mr. J. T. Dunn, in the Fuel section, makes frequent references to our columns. Mr. Alwyne Meade, in Destructive Distillation, does not refer to the electric precipitation of tar fogs which has given very promising results. In the section on Colouring Matters and Dyes which, we are sorry to see, Dr. Gilbert T. Morgan, F.R.S., is contributing for the last time. Dr. Morgan directs attention to the importance of the amalgamation of British Dyes, Limited, and Messrs. Levinstein into the British Dyestuff Corporation, to the Board of Trade scheme of assisting the British dye industry, and to the chief manufacturing firms, before dwelling upon scientific progress. Paper yarns, Mr. J. F. Briggs (Textiles) considers, may come into serious competition with jute. Germany and Austria were supposed to produce some 200,000 tons or 300,000 tons of these yarns per annum in 1917; both the brown and the white fabrics lent themselves well to dip-dyeing and colour-printing, and though they were a dismal failure for clothing purposes, they made good curtains and possibly table cloths. Mr. C. O. Bannister opens the section on the Metallurgy of Iron and Steel with the rather surprising statement that the adaptation and modification of plant for the recovery of potash from blast-furnace gas has been the most striking feature in the development of the iron and steel industry; some people are afraid that the freedom from dust will be more tangible than the 20,000 tons of potash to be recovered. In Non-Ferrous Metals (Mr. G. Patchin) the flotation of graphitic gold ores (P. T. Bruhl) is interesting; according to Parmelee the flotation oil adheres to sulphides, and interferes with subsequent cyanidation, unless removed by roasting, but does not adhere to non-sulphidic ores.

As regards Indiarubber (Dr. F. Twiss) the rapid rise in the production of the last years came to a stop in 1918. The totals for the years 1913, 1914, 1915, 1916, 1917, 1918, were, in tons: 108,440, 120,380, 158,702, 201,598, 256,879, 260,000, and the increase was almost entirely due to plantation rubber, the corresponding figures for which were: 47,618, 71,380, 107,867, 152,650, 204,251, 210,000 tons; the wild rubber production of Brazil and of other countries has rather decreased than increased since 1910. In Central Europe *euphorbia cyparissias* (the common milk weed) and *tithymalus peplus* have been cultivated for rubber and also fat extraction, while in America resinous rubber has been prepared from the "giant" and the "dwarf rabbit bush." These new sources and the synthetic rubber will hardly be able to compete with plantation rubber, particularly when we consider that science has so far done very little for plantation rubber, whilst it has doubled the sugar yield of beet roots in thirty years.

In our review of the second of these volumes* we had to comment upon a regrettable tendency of some of the compilers to speak generally of "a new apparatus" without giving the name of the inventor. The nameless patents have now disappeared. Some of the contributors have not shaken off their preference for vague general descriptions of "new apparatus" of very questionable novelty. But on the whole the present volume with its carefully-compiled index will be found very useful.

La Probabilité dans les Tirs de Guerre. Par Jean Aubert, Lieutenant d'Artillerie. Paris: Gauthier-Villars et Cie. [Price 6 francs.]

This little book of 130 pages is introduced by Professor d'Ocagne, well known as the foster-parent, if not the "onlie begetter" of nomography. In the introduction we are told how the book came into existence. The author, a young officer in the French artillery, worked out the problems which arose in his active service. During the inaction enforced by his wounds, he brought his solutions into orderly form, adding such matters of general theory as might be necessary to make the treatment coherent. The book is divided into four chapters and an appendix, entitled respectively: Theory of Errors; Gunnery in an Invariable Atmosphere; Gunnery in a Variable Atmosphere; Actual Gunnery, and the Summation of Random Magnitudes. The first chapter is the usual theory lucidly and briefly put, and the second chapter gives more or less elaborately, but with much freshness of view, the substance of the classic treatment to be found in Cranz or Ingalls. The author emphasises the fact that the mean point of impact is not generally on the centre of the target; to the resultant effect he gives the name "relative efficiency," and he provides a parametric chart for its easy evaluation. An interesting treatment is given of the theory of ranging and calibration, and though it is unlikely that such a thorough study would be acceptable in our own army, we would strongly recommend that such matter should be kept in view when the G.A.T. and T.B. of G. are re-written. Professor Greenhill has often, and with justice, pointed a sarcastic finger at our military text books, but in comparison with the pamphlet before us, nothing short of ridicule would be fitting.

The third chapter is, from the artillerist's point of view, the most novel, as it embodies an attempt to analyse atmospheric variations after the manner of Gauss; we are inclined to think that Carlyle, had he read this chapter, would have called it a piece of "wiredrawn ingenuity." There can, however, be no doubt that the problem attacked, has an increasing practical interest, especially with reference to the drum fire of modern artillery, from which we suspect the author has derived suggestion.

In his fourth chapter, which deals with the theory of fire under actual conditions, the author emphasises the theoretic nature of Gauss's law, and he shows that it can never fully express the results of actual gunnery. This view, admittedly an echo from Colonel Henry, is refreshing in comparison with the complacency of earlier writers, who point to the extraordinary agreement between the theory and the facts. At the same time, though it is far from our intention to derogate the brilliant work of a young writer who is still a student, we feel that he labours his points occasionally. Not even a regular officer of the Royal Regiment would expect Gauss's law to hold for a gun with a rapidly-wearing or coppering bore. Nor would he see anything mysterious in a stiff breeze; we are reminded of Lemuel Gulliver's impressions of the Brobdignagian ladies' pores. The law of Gauss can be logically deduced from clearly definable premises, and if these premises can be realised in actual conditions, we know, so far as we know anything, that the law will be realised in the results. The errors of the gun, of the day, and of the observer cannot easily or profitably be reconciled to the assumptions underlying Gauss's law; they are more plausibly systematic errors.

This little book is not strictly speaking an engineer's book, except for the few ordnance experts, who must now be seriously concerned for their future employment. We have discussed it, nevertheless, with comparative fullness for two reasons. In the first place, it is a valuable contribution well deserving of notice, and in the second, it contains among other matters, a clear and succinct view of a method of thought which will become increasingly important in an epoch of large-scale organisation and production where statistical analysis may be necessary; a method of thought which helps to banish the atmosphere of chance from things that appear to be merely chances.

THE WORKS AND PRODUCTS OF MESSRS. BARR AND STROUD, LIMITED.

(*Concluded from page* 779.)

We have already made it clear that Messrs. Barr and Stroud's main concern has always been the manufacture of rangefinders, but from time to time apparatus auxiliary to rangefinders, has been designed and made. This in turn has led to the taking up of other lines of work in the development of their business. In this, the concluding article of our series, we may fitly make reference to some of this other material which Messrs. Barr and Stroud manufacture, although we cannot attempt to deal with this aspect of the firm's activities other than briefly and incompletely. As an example of what we mean by apparatus auxiliary to rangefinders, we may refer to the fire-control gear which has been an important branch of the firm's work for a number of years and has been fitted to a very large number of ships of the British and other navies.

The apparatus is an electrical one, by means of which visual signals are transmitted from the fire-control platform of a warship to the various gun stations. The arrangement may in a general way be likened to the ordinary engine-room telegraph, as it is made up of transmitters and receivers and the operation by hand of the transmitter to bring one signal into view results in the reproduction of the same signal on the receivers. The interesting feature of the apparatus lies in the very simple electrical arrangement which is used and the absence of escapements, wound armatures or other frail parts. The transmitter may be looked upon as a

* See Engineering, December 13, 1918, page 689.

hand-operated commutator and requires no comment, but some description of the receiver is necessary. This consists of three horseshoe electromagnets lying parallel side by side. Between the pole pieces of each magnet there rotates a soft iron armature. The three armatures are of cylindrical form—corresponding to the cylindrical pole pieces of the magnets—and are fixed across a common spindle at 120 deg. to each other. Thus in one position one armature bridges the gap between the pole pieces of its electromagnet, but through only 30 deg. It will be obvious that by energising and breaking the circuits of the various magnets in the proper order the common spindle will be caused to rotate in steps and that twelve positions of rest, corresponding to twelve signals, will be given in the full revolution. The arrangement is a remarkably simple one for the results achieved. It is necessary to jump or miss three steps on the transmitter before the receiver can take up a false position relative to the transmitter, or before one receiver can get out of step with another.

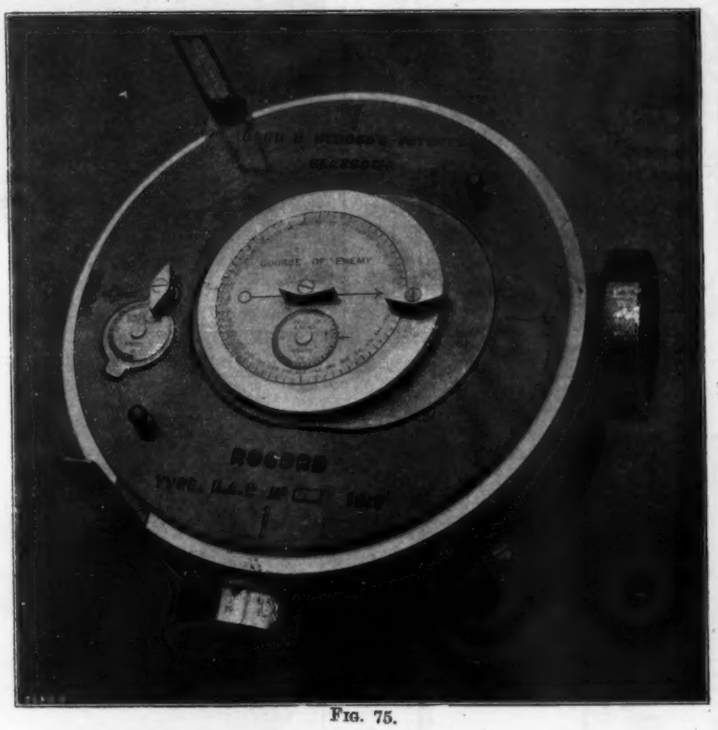
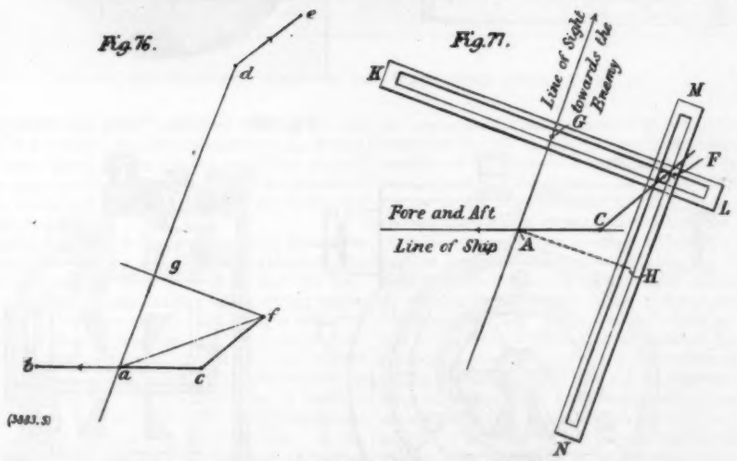


FIG. 75.



FIGS. 75 TO 77. FIRE-CONTROL GEAR FOR WARSHIPS.

the other armatures are 60 deg. out of correspondence with the pole pieces of their electromagnets.

The arrangement operates on a step-by-step method. When current is being supplied to the first magnet (say A) the armature A lies so that it bridges the gap between the pole-pieces of the magnet A. If, then, the circuit of A is broken and B is switched in, the armature of B will move to bridge its gap and the common spindle, and with it the indicating drum, will rotate through 60 deg. If, however, B is switched in without the circuit of A being broken, then the armatures of A and B will take up a common position of balance and the main spindle will rotate

A piece of apparatus auxiliary to the fire-control gear is illustrated in Fig. 75 annexed. This is designed for the purpose of automatically determining, and electrically transmitting to distant stations, the rate of change of range and the deflection of a target. It is known as the "Rocord." The instrument is intended to be set up in some position, such as the control top, where an all-round view can be obtained, and, acting in the same way as the transmitter of the fire-control gear, indicates on distant receivers the rate of change of range and the deflection of an enemy ship. The instrument is not one of precision, since it indicates in terms of estimated quantities, but has the advantage of transmitting a continuous record of a moving target. The Rocord operates in terms of four quantities—(1) the known line of sight between the ship on which it is mounted and the target, (2) the known speed of the ship, (3) the estimated speed of the target, and (4) the estimated course of the target relatively to the ship. From these it automatically determines the rate of change of range and the deflection of the target.

The principle on which the instrument operates may be explained by reference to Fig. 76 on this page. In this diagram point *a* represents the ship and the vector *a b* its course—that is, its direction and speed. Point *d* represents the enemy ship and vector *d e* the enemy's estimated course relative to *a*. To determine at any moment the value of the rate of change of range between the two ships, and the deflection, one may plot the triangle *a c f*, in which *c a* is parallel and equal to *a b* and *c f* is parallel and equal to *d e*. This gives a resultant *a f*, which represents the course and speed of the enemy *d* relatively to the ship *a*. This resultant may then be resolved into two rectangular components, one *a g* along the line of sight *a d* and the other *g f* at right angles to the line of sight. The length *a g* will then represent the rate of change of range and *g f* will represent the deflection. Figures corresponding to these two lengths are automatically transmitted by the Rocord to the receiving instruments in various parts of the ship.

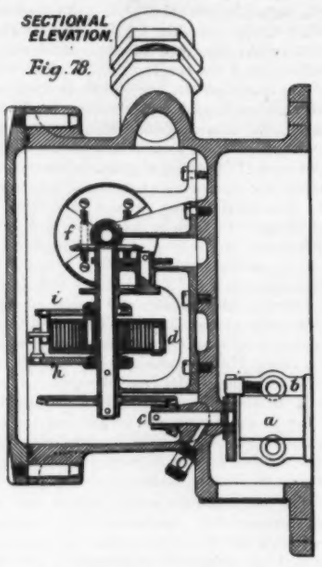
The mechanical devices which are used in the instrument for automatically determining the value of the two components *a g* and *g f* are illustrated in Fig. 77 annexed. The position A in this figure represents the ship and is situated in the centre of the instrument. It corresponds to point *a* in Fig. 76. The point C, which is fixed on the fore and aft line of the ship, can be moved along this line so that A C can be adjusted to correspond with the speed of the ship. The position of point C is adjusted in the actual instrument by the small thumb handle shown to the left-hand side in Fig. 75. The small dial shown in association with this handle indicates ship's speed and is operated by this handle at the same time that the position of point C is adjusted. In using the Rocord the dial is, of course, set to the known speed of the ship at the time the observations are being taken. The fore and aft line, corresponding to the line A C, is marked on the Rocord case, as shown in Fig. 75, and this line is set in the fore and aft line of the ship.

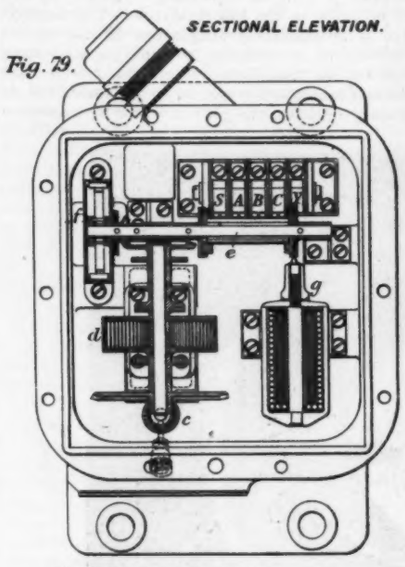
Referring again to Fig. 77, it will be seen that to the pivot C there is attached an arm C F. This can be rotated in accordance with the course of the enemy's ship, and the pin F can be displaced along the arm C F in accordance with the speed of the enemy's ship. The positions of the arm C F and the pin F are determined by the two thumb handles to be seen on the centre dial of the instrument in Fig. 75. The centre handle operates the small dial, which has to be set to the estimated speed of the enemy. The other handle operates the large dial showing the course of the enemy, and this dial has to be set so that the arrow which it carries appears to be parallel to the fore and aft line of the enemy's ship. The only other operation which has to be carried out by the observer is the working of the training handle, which can be seen in Fig. 75, so as to keep the fore sight always upon the target. The turning of this handle rotates the outer case carrying the sights. The upper plate carrying the fore and aft marks, the thumb handles, &c., does not rotate.

Returning now to Fig. 77, the operation of the instrument may be explained. The parts of this figure already referred to, that is, the pivots A and C and the arm C F, are mounted in conjunction with the upper plate of the instrument to which we have just referred. They have no rotational motion relative to the ship and the line A C always lies in the fore and aft line of the ship. It will be seen from the figure that the pin F engages the slots of two sliding bars L K and M N, arranged at right angles to each other. These bars are mounted on a guide frame which is attached to the case carrying the direct sights. They accordingly rotate as a whole round the centre A as the handle is operated to keep the sights directed on the target. The bar L K is the rate of change of range bar. It occupies a

WATERTIGHT DOOR INDICATORS FOR SHIPS' BULKHEADS.

CONSTRUCTED BY MESSRS. BARR AND STROUD, LIMITED, ENGINEERS, ANNIESLAND, GLASGOW.





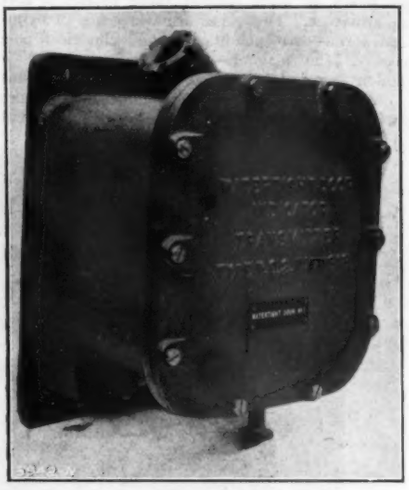
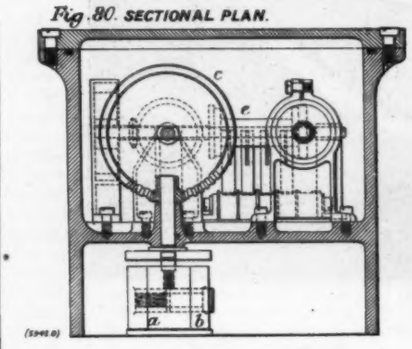


Fig. 81. General View of Transmitter.



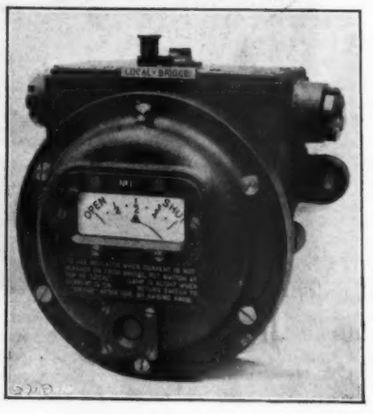
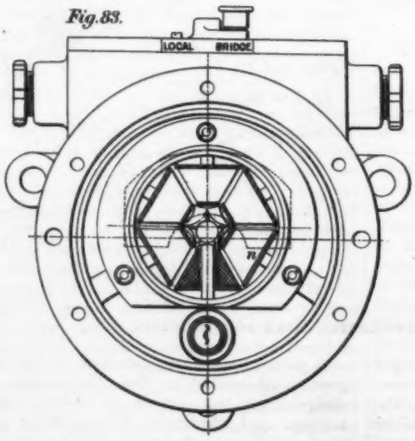


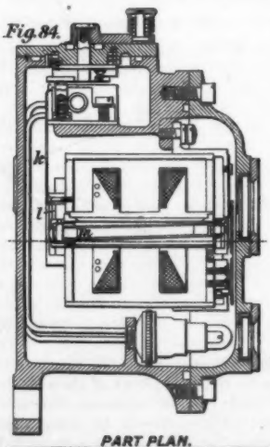
Fig. 82. General View of Receiver.

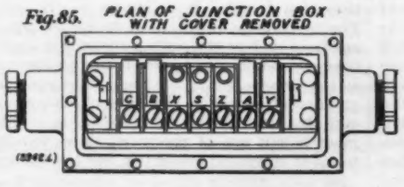
position always at right angles to the line of sight and can move to and fro along that line. The bar M N is the deflection bar. Its slot always lies parallel to the line of sight and it can move in a direction at right angles to the range bar.

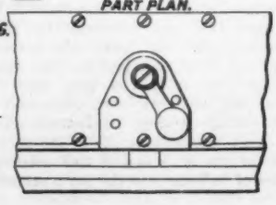
It will be evident from the construction, that as the line of sight varies, and the outer case carrying the two bars is correspondingly rotated, the bars engaging the pin F will slide along and parallel to the line of sight respectively, and that accordingly the rate of change of range and the deflection indicated will depend upon the distances A G and A H of the two bars from the centre A. The linear motions of the two bars are converted into rotary motions by means of racks and pinions which drive commutators similar to those used on the transmitters forming part of the fire-control gear described above. The brushes of the commutators bear on slip rings on the fixed base of the case, and these slip rings are connected to the terminals of the indicating receivers. As already stated, the top plate carrying the course and speed dials remains stationary relatively to the ship when the case is rotated. This effect is obtained by gearing a large diameter wheel attached to the base with a wheel of equal diameter attached to the top plate through a 1 to 1 ratio, comprising two equal pinions in mesh with the two wheels and secured to a vertical shaft carried by the casing and rotated by the training handle. The rotational effect of the case upon the top plate is exactly neutralised by the gearing, and the plate, therefore, remains stationary relatively to the ship.

The remaining figures which accompany this article illustrate Messrs. Barr and Stroud's indicating gear for ships' watertight doors. Briefly, the arrangement consists of a transmitter situated at, and operated by, the movement of each door, and a receiver, or receivers, situated in any convenient place, or places, on the ship. The gear, which is an electrical one, is, of course equally suitable for merchant vessels as for warships and is being fitted to a number of important liners. To describe the operation of the gear it will be best to first refer to the transmitter, of which various sectional views are given in Figs. 78 to 80, and a general view in Fig. 81, all on the present page. The transmitter is connected to a shaft of the door operating gear, shown at *a* in Figs. 78 and 80 by means of a coupling *b* clamped on to the shaft end. This coupling, as will be seen from the figures, can be rotated on the shaft *a*, when the transmitter is first being adjusted into phase with the movement of the door. The coupling drives a bevel gearing *c* through a pin in the way the figures clearly show.









The main bevel is pinned to a vertical shaft carrying the spring-box *d*. This spring-box is an important feature of the apparatus. Its duty is to protect the commutator and more delicate parts of the transmitter from shocks and from too rapid movements, and also to insure that the indicators shall operate correctly when current is switched on, even if the doors have been operated while the current was off.

Before saying anything further in detail about the spring-box, it will perhaps assist understanding of the transmitter if the main parts are briefly mentioned. It will be seen that the vertical shaft already referred to carries a further bevel wheel at its top end. This wheel, which is driven from the spring box and is not attached to the vertical shaft, drives a bevel wheel secured to the horizontal shaft carrying the commutator *e*. At one end this shaft carries a governor *f*, and at the other a toothed wheel, which is acted on by the electrically controlled detent *g*. With this explanation the general method of operation of the transmitter should be clear. The opening or closing of the water-tight door rotates shaft *a* and this in turn rotates the commutator *e* through the intermediation of the spring box, and the two bevel gears. Brushes bearing on the commutator connect to the terminals S, A, B and C, and from these points are led away the control wires to the receivers. The purpose of the governor and the electrically operated detent we will refer to in a moment.

Returning now to the spring box *d*, it should be explained that the top and bottom portions of the box are independent from each other and are connected together only by the flat spiral spring which lies inside. The inner end of the spring is attached to the upper part of the box and the outer end to the lower. The two parts of the box are rotated under the action of the arm *h*, which is secured to the vertical spindle. This arm carries a vertical pin at its outer end, which engages with projections on the top and bottom halves of the box. If the arm is rotated in a clock-wise direction it carries the top part of the box with it in the same direction, and if this rotation is carried out at the normal working speed of the instrument, the lower, or driven, part of the box will follow on immediately under the action of the spring. The spring, it should be explained, is put into the box under an initial tension, so that there is always a force applied by the projections on the half boxes between the pin on the driving arm *h* and the pin on the upper corresponding driven arm *i*. The force which is applied in this way, when the instrument is at rest, is greater than the frictional resistance of the gearing and the commutator brushes, with the result that when the instrument is operated at not more than normal speed, the spring box moves as a single unit. If, however, the driving arm is operated quickly, owing to the water-tight door being moved rapidly, the top part of the box moves on ahead of the lower part which follows at normal speed under the combined action of the spring and the governor *f* on the commutator shaft. The gear ratio of the bevel drive *c* is such that for a complete movement of the water-tight door from open to shut, the spring box makes slightly less than one revolution.

The commutator consists of a phosphor-bronze sleeve, with projecting contacts formed on its outer surface. The sleeve is mounted on a glass insulator supported by ebonite end caps which are fixed to and rotate with the spindle *e*. Contact springs are provided on the terminals S, A, B and C, and these bear on the commutator sleeve and distribute current to the live wires connected from A, B and C, S being the supply terminal. The commutator contacts are formed so that only one live wire is in circuit at a time. One revolution of the commutator makes three contacts between supply terminal S and the live wires, that is each of the live wires A, B and C comes once into circuit. There are 32 steps arranged for between the open and shut positions of the watertight doors, so that the commutator has to make 10⅔ complete r volutions for the full movement in one direction. This number of revolutions is arranged for by the upper bevel gearing driven from the upper half of the spring box. The governor *f*, fixed on the end of the spindle *e* which carries the commutator, consists of a pair of weights, rotating inside a case, and carried from a hub fixed to the spindle. They are held towards the centre by two light spiral springs. If the speed of revolution of the spindle *e*, and consequently the commutator, tends to become too high, the weights move outward and their friction against the containing case checks the speed.

The detent *g*, to which we have already referred, may be looked upon as forming part of a magnetic clutch. The arrangement consists of a solenoid carried in a bracket fixed to the base of the instrument. The armature is in the form of a plunger and is attracted by the electromagnet against the action of a spring. When the current is off the spring forces the armature away from the magnet and carries the detent into engagement with the toothed wheel fixed to the commutator. The solenoid coil is permanently connected across the supply, from terminal S to terminal Y, which is the return. When current is switched on, the detent disengages the commutator and the instrument is free to operate in the manner we have described. If, however, the watertight door is moved when the current is off, the lower driving arm *h* will wind up the spring to a proportional extent as before, but the upper half of the spring-box and the commutator will not follow on owing to the detent *g* being engaged with the toothed wheel on the armature. Immediately the current is switched on, however, the commutator will be released and will rotate to the correct extent, being finally stopped by the driven arm *i* coming to rest between the projections on the two halves of the spring-box.

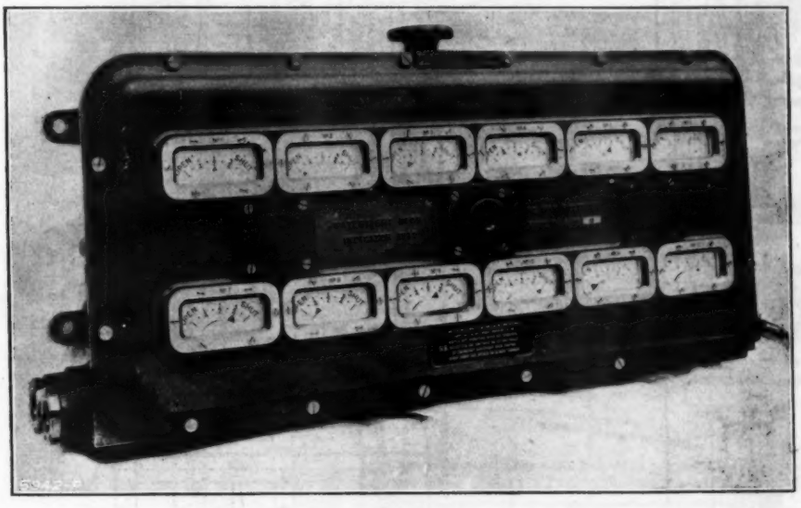


Fig. 87. Multiple Receiver for Watertight Door Indicator.

The receiver is illustrated in Figs. 82 to 86, on page 848, Fig. 82 being a general view and the remainder sectional views and details. A view of a multiple receiver, containing dials indicating the movement of a number of different doors is illustrated in Fig. 87, annexed. In describing the receiver we will refer to the single type illustrated in Figs. 82 to 86. As will readily be understood, the multiple instrument is merely an assembly of a number of single instruments in one case. The receiver consists of a pointer working over a dial and driven from an armature by internal gear wheels. The pointer makes 32 steps from the open to the shut position of the watertight door. Connection is made from the transmitter commutator through the line wires to the terminal blocks A, B and C, shown in Fig. 85. From these blocks the current is led by springs *k* to contacts on the rotor frame *l*, which in turn are connected to the corresponding stator coils *n*. The arrangement of the rotor is of great interest and ingenuity. It consists of a bar-like construction of soft iron working in a ball joint at its bottom end. As will be seen from Fig. 83, it is star-shaped in cross-section, having five sides, each of which is concave. These concave surfaces fit on to corresponding convex surfaces on the stator poles. In Fig. 83 it may be assumed that the lower stator coil is energised and that the rotor is attracted down on to its pole face. If now the next coil is energised and the circuit of the lower coil is broken, the rotor will roll over on to the next pole face. In doing this it will operate the pointer through the internal gearing, and the pointer will indicate one step on the dial. The stator coils *n* are connected in pairs diametrically opposite, *i.e.*, in the position shown in Fig. 83 the lower and the upper stator coils are both energised. When the next pair of coils on either side is energised the rotor will roll over to the nearer pole-face. There is no tendency for the rotor to jump to the opposite pole-face, owing to the formation of the armature and the longer air-gap.

Space has permitted us to describe only a few of the many appliances that Messrs. Barr and Stroud have invented and constructed during the thirty-two years they have devoted to meeting various requirements of the services as these arose, more especially in regard to rangefinding and fire control. While they purpose in the future to continue their work on rangefinders, fire control instruments, periscopes for submarines and other apparatus for naval, fortress and field services, their works are much too extensive on both the optical and mechanical sides to be kept in full operation on war material as at present in demand. They are therefore turning their attention to civilian work of a variety of kinds, among which may be mentioned Galilean and prismatic binoculars; kinematograph projectors for halls and smaller and simpler types for college, school and home use; the Optophone—an instrument by which the blind are enable to "read" ordinary printed matter; and internal combustion engines for motor cycles.

Iron and Steel Industry in South Africa.—We understand, says *The South African Mining and Engineering Journal*, that it has been decided to extend the Pretoria iron and steel industry to realise its full possibilities, and that capital running to one and a half millions is assured for the undertaking. It is noteworthy, in this connection, that Mr. Mackie Niven, speaking at a colliery company meeting last week, said: "Several small blast furnaces have been erected in the Transvaal during the past two years and these had, from native ores, been turning out about 10 tons of pig-iron per day. These experimental plants had demonstrated that pig-iron, of first-class quality, could be produced in this country. The pre-war price of pig-iron in Britain was so low that manufacturing was not possible. The price now was very high. Authorities did not anticipate it would be likely to fall to anything like the old price, perhaps not lower than double the old price, for many years to come, if ever. The question of establishing a large iron and steel industry in South Africa was therefore being seriously considered—a decision was not likely to be taken in a hurry, as it might involve the expenditure of millions of money.

25-H.P. FOUR-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. VAUXHALL MOTORS, LIMITED, ENGINEERS, LUTON.

(*For Description, see opposite Page.*)

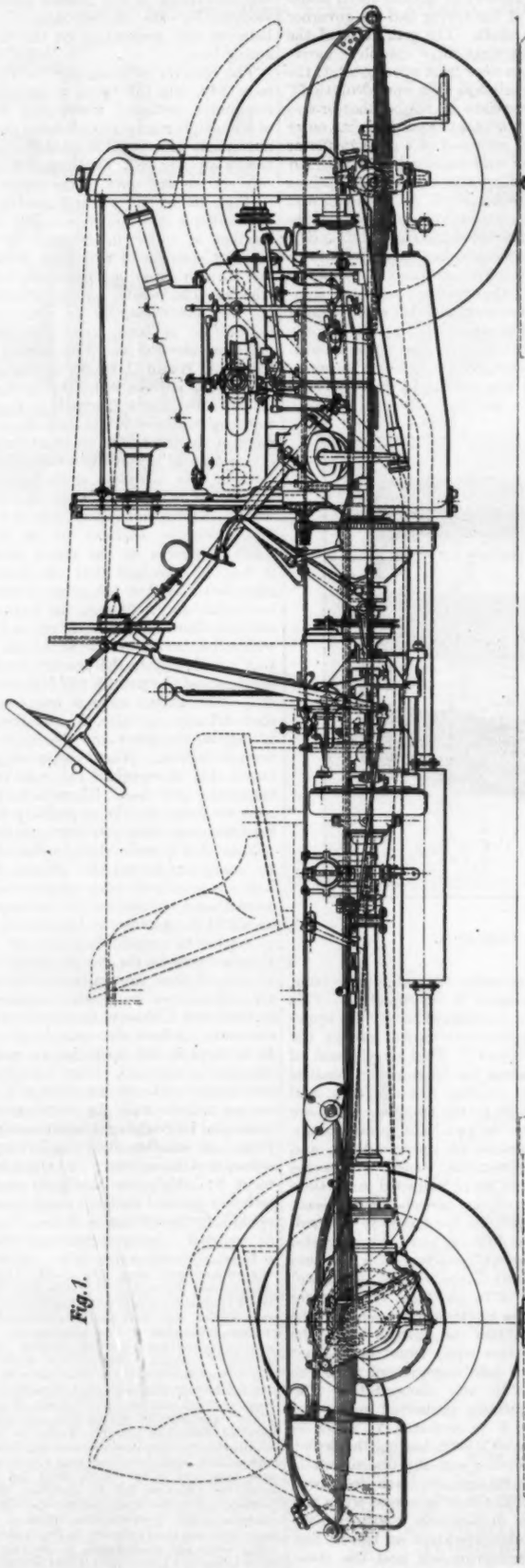


Fig. 1.

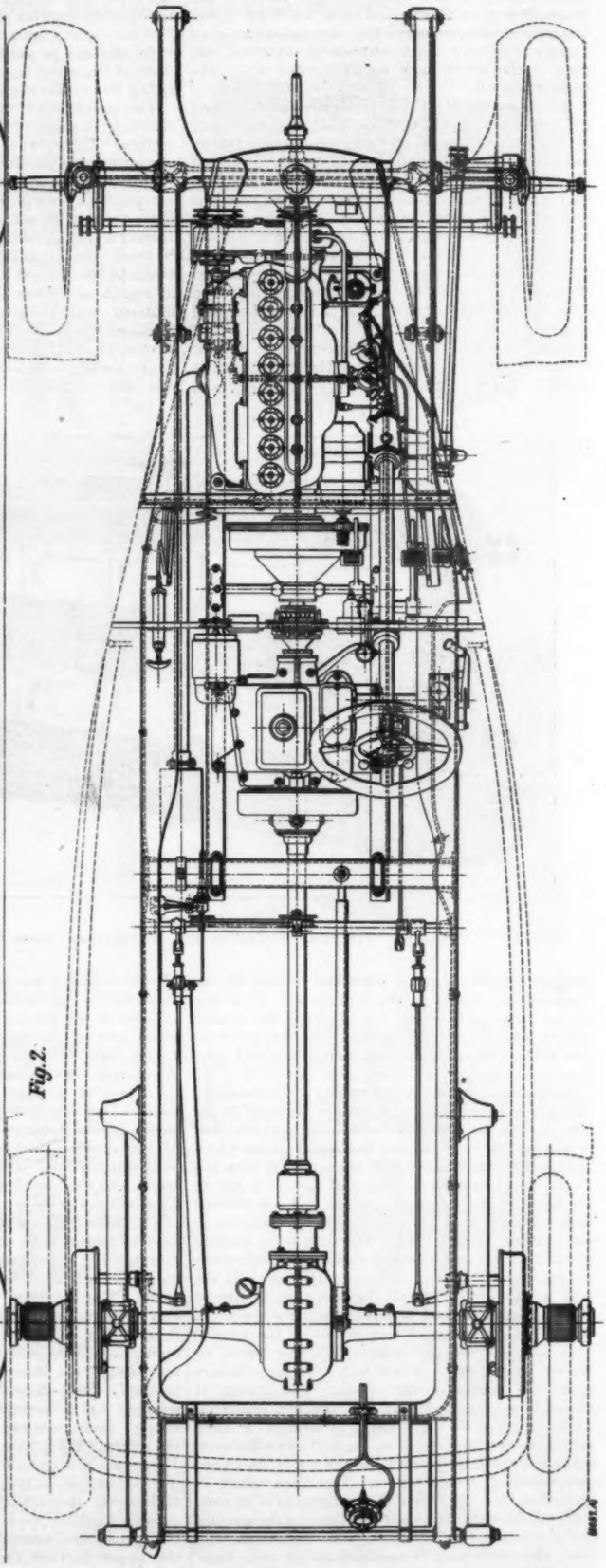


Fig. 2.

25-H.P. FOUR-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. VAUXHALL MOTORS, LIMITED, ENGINEERS, LUTON.

Fig. 3.

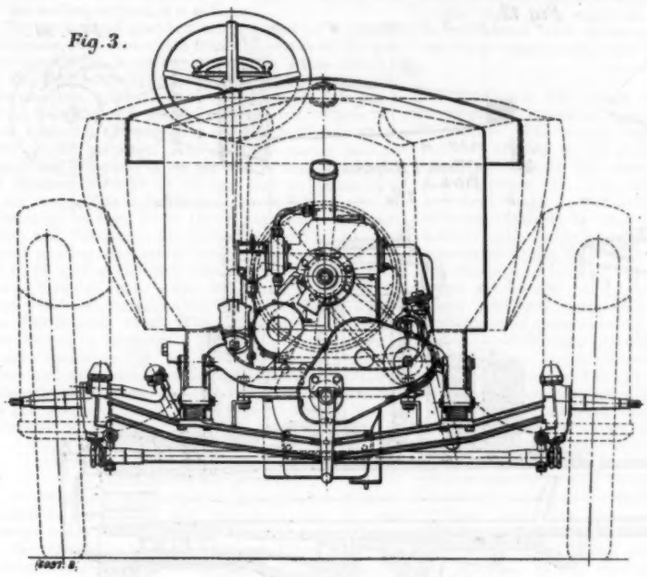


Fig. 4

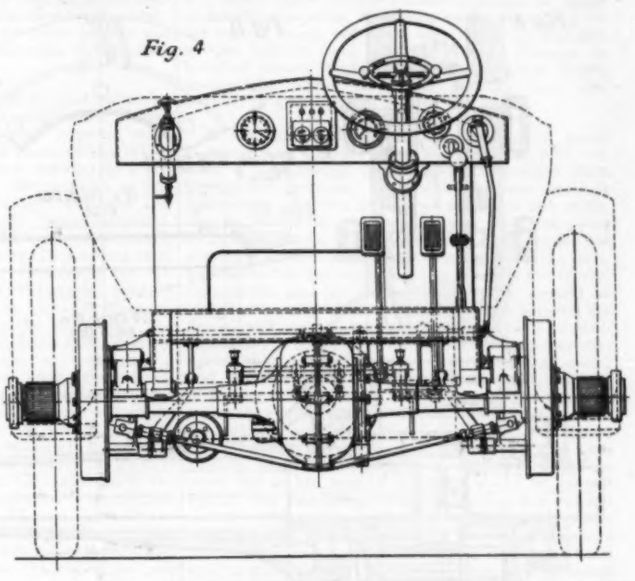
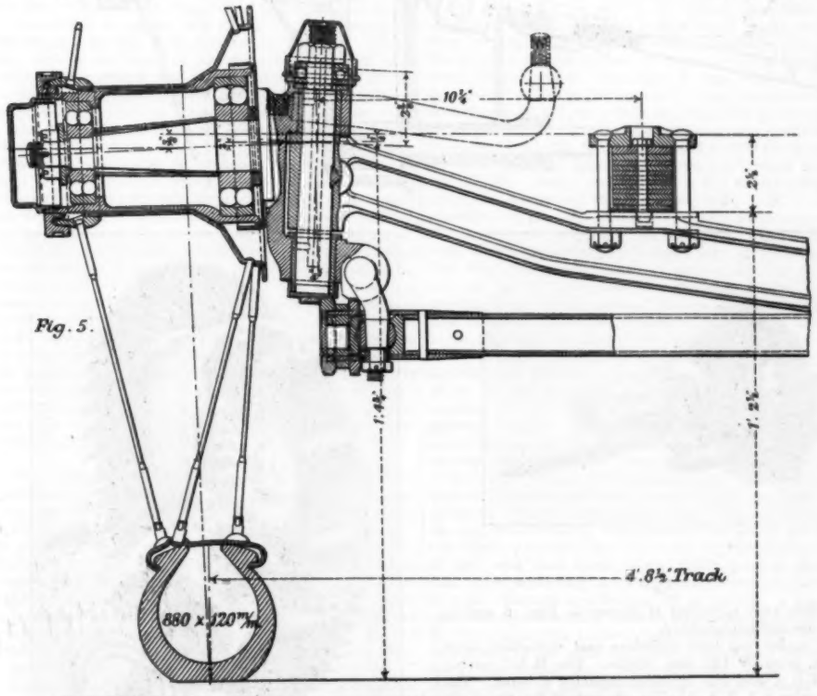


Fig. 5.



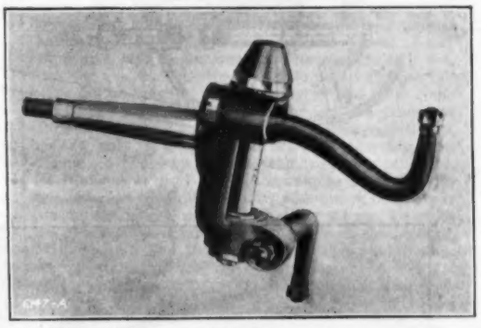


FIG. 8.

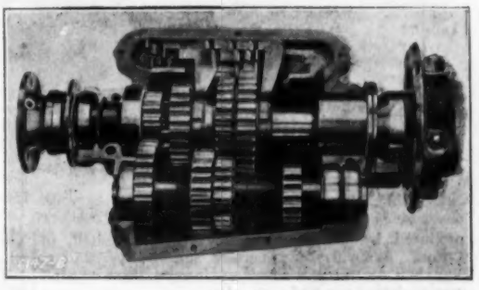


FIG. 9.

Fig. 6

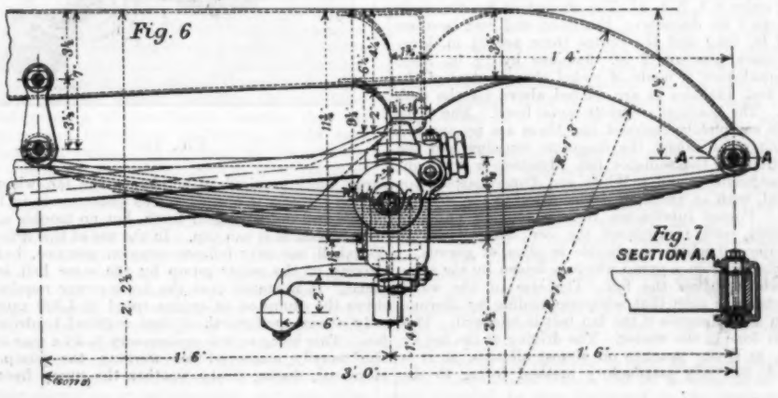
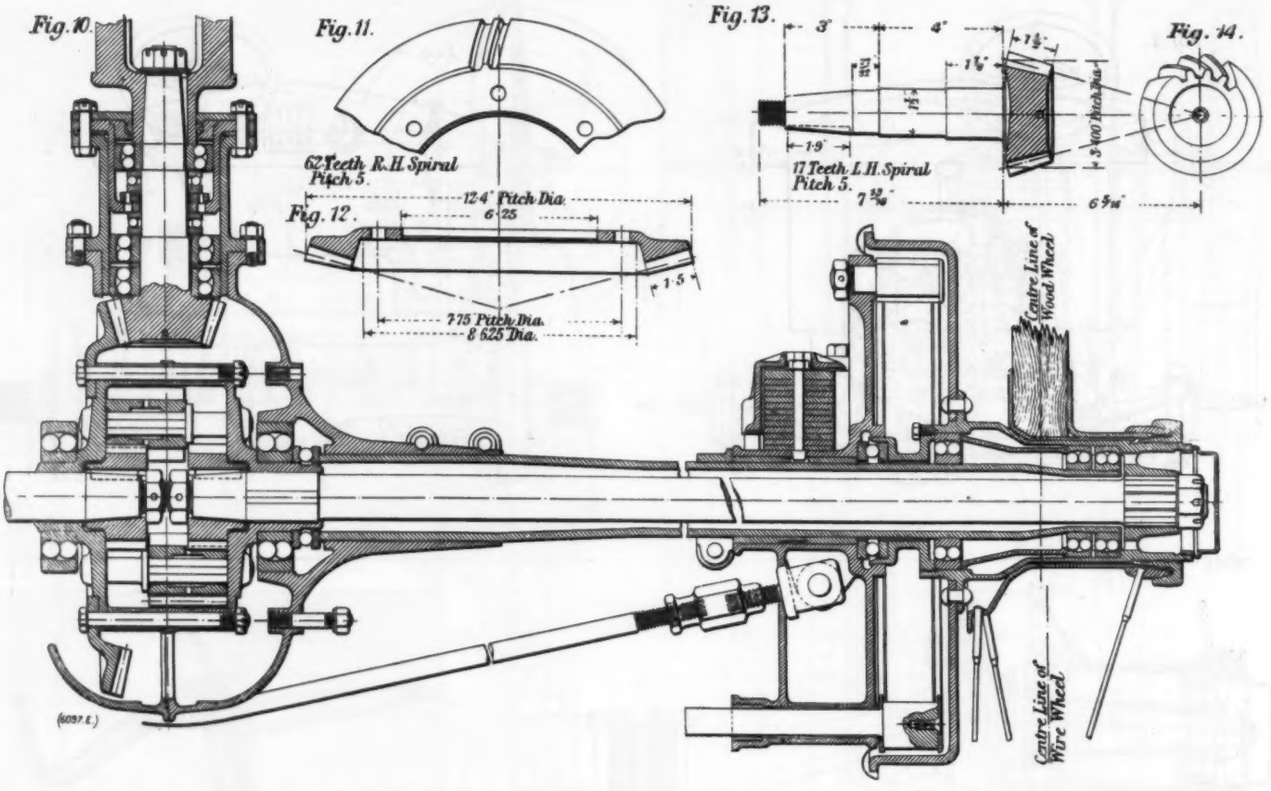


Fig. 7
SECTION A.A

THERE are plenty of exceptions, but in a general way modern motor cars divide themselves into fairly definite classes. Light cars apart, there are three main groups. These respectively cover the smaller car of about 10 h.p., the medium-powered car of, say, 20 h.p. to 25 h.p., and the high-powered and more luxurious model. Each type has its particular sphere, but to the engineer there is, we think, something specially attractive in the medium-power class. The smaller-engined cars necessarily suffer somewhat in speed and roominess, while the large and powerful cars are perhaps apt to take on too many refinements, and in any case their price lifts them to some extent out of the ordinary run of the workaday world. The medium car on the other hand may well be all that a motor car need be and at the same time the price is not such as to prevent it being an ordinary tool of common and extensive use. A good example of a modern good-class medium-powered car is illustrated in the figures which accompany this article and which show the 25-h.p. four-cylinder model which is being

25-H.P. FOUR-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. VAUXHALL MOTORS, LIMITED, ENGINEERS, LUTON.



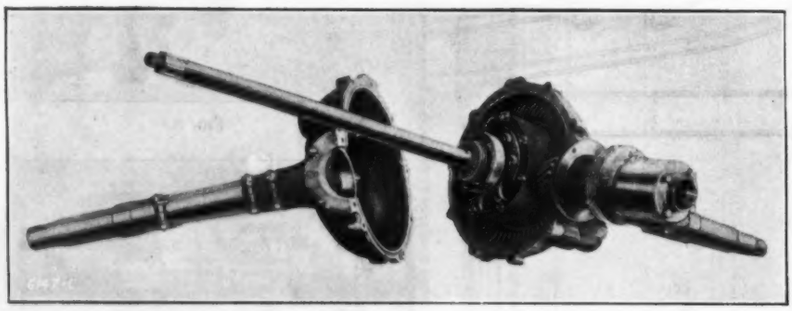


FIG. 15.

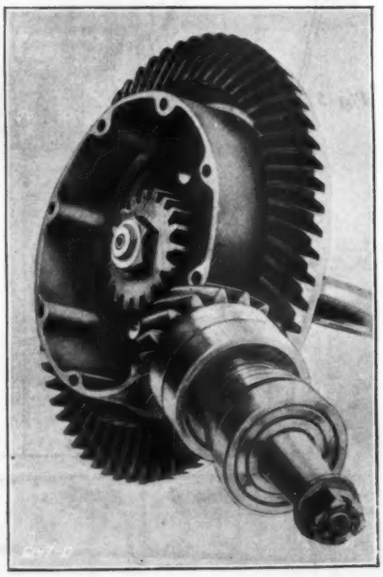


FIG. 16.

produced by Messrs. Vauxhall Motors, Limited, of Luton. As will be generally known the 25-h.p. Vauxhall car made a considerable reputation on staff service during the war.

The chassis, shown in Figs. 1 to 4, on pages 850 and 851, has a 10-ft. 10-in. wheel base, and a 4-ft. 8-in. track. The width over the frame is 2 ft. 11 in. and the overall dimensions 15 ft. by 5 ft. 8 in. Detachable wire wheels are fitted carrying tyres 880 mm. by 120 mm. The springs, both front and rear, are of the semi-elliptic type. The body fitted to the touring model carries five persons. The weight of the chassis, including starting and lighting installations, is 26 cwt. The general construction of the frame will be clear from Figs. 1 and 2. The front axle, in position in the car, is shown in Fig. 3, while Fig. 5 is an enlarged sectional view showing half of the front axle and one of the front wheels. A perspective view of one of the stub axles is given in Fig. 8. The front axle is of H-section and is made of steel having an ultimate strength of 40 tons, an elastic limit of 25 tons and a 30 per cent. elongation. The stub axles are of nickel-chrome steel of 50 tons ultimate stress, 40 tons elastic limit and 20 per cent. elongation. The inclined steering pivots are completely enclosed and are lubricated with oil. The ball valve lubricator is shown in Fig. 8. The steering gear is of the worm and wheel type. The front axle springing is shown in Figs. 6 and 7, which are self-explanatory.

The engine has four cylinders cast monobloc, each 95 mm. bore by 140 mm. stroke. The R.A.C. rating is 22·4 h.p. and the cylinder capacity 4 litres. The firing order is 1, 2, 4, 3. The crankshaft has five main bearings 2 in. diameter; the front and rear bearings are 3 in. long and the centre three are 2¼ in. long. The crank pins are 2 in. diameter by 2¼ in. long. The crankshaft is made of nickel chrome steel of the same test qualities as are quoted above for the stub axles. The bearings are white-metal lined. The valve gear is completely enclosed and there are no exposed working parts except the magnetic coupling and the belt drive to the radiator fan. Ignition is by high-tension magneto and a White and Poppe carburettor is fitted, with an extra air device fitted to the steering wheel. Forced lubrication from a plunger pump is employed, and throughout the car ball oil valves are employed wherever possible in place of greasers.

Cooling is from a pump which is driven by the same belt which drives the fan. The size of the water connections is such that adequate cooling by thermo-syphon action ensues if the fan belt is removed. This may be done in the winter. The driving of the fan by a belt, as is the practice on almost all cars, is, it is claimed, the only satisfactory method owing to the large effort required to accelerate the fan when the engine throttle is opened. This effort tends to break chains and ordinary gear teeth, but no trouble occurs with a belt, as it can slip. In the use of this drive the Vauxhall car only follows common practice, but the driving of the water pump by the same belt is less usual. It is stated that the horse-power required to drive the pump at an engine speed of 1,500 r.p.m. is only about one-fortieth of that required to drive the fan. This being so it is unnecessary to fit a gear of the size usually employed for working the pump. If, moreover, during frosty weather the pump freezes a

breakdown of the driving mechanism will occur when the engine is started if a positive gear is used. In the Vauxhall design the belt merely slips. The adjustment of the belt is provided for by making the pulley on the fan spindle of the adjustable cone type. The capacity of the cooling system is 6 gallons.

The engine and gear-box are mounted on a common sub-frame, and connection from the clutch to the gear-box is through a universal coupling. The clutch is of the multi-disc type lubricated with dry graphite. The gear-box, an illustration of which is given in Fig. 9, gives four forward speeds and reverse. There is a foot brake on the propeller shaft immediately at the rear of the gear-box. The gear-box casing, and the crank-case are made of 96 per cent. aluminium, having an ultimate strength of 13 tons and an extension of 5 per cent. The final transmission and back axle are illustrated in Figs. 10 to 16, on page 852. The main drive and differential are well shown in Fig. 10. The bevel gearing has spiral teeth as detailed in Figs. 11 to 14, and as shown in perspective in Fig. 16, while the differential axle drive has straight teeth. The road wheels are carried on sleeves so that the axles are of the full floating type. The rear-wheel brake drums are 16 in. in diameter. The whole arrangement is clearly shown in Fig. 10. The gear shafts, propeller shaft and axles are of nickel steel having an ultimate strength of 40 tons, an elastic limit of 28 tons and 30 per cent. elongation. The gear wheels are of case-hardened nickel steel.

INDUSTRIAL NOTES.

IN the course of his reply to a deputation of manufacturers, merchants and representatives of trade unions which waited on him recently, with reference to the dislocation of traffic in South Wales, the Prime Minister stated that the real cause of congestion was the war. The average wagon had had to be run until it almost fell to pieces, the manufacturing energy of the country having been devoted to the war. There was also a shortage of locomotives. Another unfortunate occurrence was the moulders' strike; owing to this strike, some locomotives were actually being stripped of parts to repair others. Further, the 8-hour day had been responsible for much of the delay. Another cause of the delay in traffic was the detention of wagons; this was 50 per cent. greater this year than it had been last year. A most serious element was the diversion of traffic from sea to land. He asked the deputation to appoint a small business committee representative of the great trades and industries of South Wales, to meet representatives of the railway companies and, if necessary, of the various Government Departments directly concerned, to see whether something could not be done to make arrangements in South Wales for once more restoring the short-sea trade. He would like Labour to be represented because he knew they were prepared to do their best to assist. He appealed to Labour to see whether they could not provide a special effort during the next twelve months, without in the least compromising the concessions which had been made, to relieve the congestion, so that trade should begin to run normally.

We recommend to our readers a small booklet, published at the price of 1*s.* net, by the Garton Foundation, 3B, Dean's Yard, Westminster, S.W. 1, entitled "The Industrial Council for the Building Industry." It gives the history of the scheme originated by Mr. Malcolm Sparkes, for the establishment of a Building Trades Parliament; it explains the steps which were taken for the formation of the council and gives information on its satisfactory working. It records the proceedings at the inaugural meeting held at the Central Hall, Westminster, on May 29 and 30, 1918, a meeting which was supported by 22 trade unions, 17 associations of employers and attended by 3 Ministers of the Crown. Sir David J. Shackleton, K.C.B., of the Ministry of Labour, presided at the opening session. A most satisfactory feature at the meeting in question and one which throws a clear light on the whole scheme, was the following:—The Provisional Committee brought forward a proposal (based probably on the time-honoured practice of conciliation boards), that the Employers' and Operatives' Federation should each elect their own quota of 10 members for the administrative committee, in such proportions as to reflect in miniature the composition of the council itself. But Mr. H. Piper, president of the National Federation of Building Trades Operatives, expressed the desire of his members to take part in the election of the employers' quota and, conversely, invited the employers to vote with them in the election of the operatives' quota. This novel and far-reaching proposal met with immediate support, and was carried without a dissentient; decision by vote of the whole council has since become the regular practice with regard to every question which comes before it. It was also decided that if an employer were elected as chairman, the vice-chair should go to an operative, and *vice versa*. The council has since held meetings in London, Birmingham, Edinburgh, Manchester and Bath, and it has done well, so the pamphlet states, adding that it has exceeded the expectations of very many. It would seem to us that the scheme and its working, as outlined in the pages from which we quote thus briefly, might be considered with advantage by trade unions and employers representing other industries in the kingdom.

According to *The Labour Gazette*, in most industries employment continued good or fairly good during November. The engineering trades, however, were seriously affected by the strike of ironmoulders, which lasted throughout the month and resulted in much unemployment and short time. Employment at iron and steel works and in other metal trades was also adversely affected by this dispute. Some industries, notably coal-mining and iron and steel manufacture, were handicapped by transport difficulties arising from the shortage of railway wagons. Changes in rates of wages which came into operation in November affected about 1,900,000 workpeople, who received increases amounting to approximately 480,000*l.* per week. The general level of retail prices of food and other items of working-class family expenditure at December 1 was approximately 125 per cent. above the pre-war level, or about the same as at November 1. The number of out-of-work donation policies lodged at November 21—the latest date for which complete statistics relating to the civilian donation are available—was 491,546, as compared with 479,427 at October 31. This increase is largely, though not entirely, due to the strike of ironmoulders. The distribution of the 491,546 policies lodged at November 21 was as follows: Civilians—men 100,320, boys 8,000, women 27,030, girls 2,287. Demobilised—men 348,955, women 4,954. In addition, 53,353 workpeople (21,398 males and 31,955 females), in grades to which the National Insurance Acts apply, had lodged their books with a view to claiming unemployment insurance benefit. The number of men on the live registers of the Employment Exchanges at December 5 was 474,314, or a decrease of 4,324 on November 7; and the number of women was 55,427, or a decrease of 30,071 on the total at November 7. The number of vacancies unfilled on December 5 was 26,152 for men and 44,300 for women, the corresponding figures for November 7 being 28,796 and 42,884. Trade unions with a net membership of 1,500,325, excluding those serving with H.M. Forces, reported 2·8 per cent. of their members as unemployed at the end of November, as compared with 2·6 per cent. a month earlier and 0·5 per cent. a year earlier. The rise since last month is accounted for by the increase in unemployment in the engineering trades arising from the moulders' strike. Employment at coal mines in November continued good; the number of workpeople employed at the collieries included in the returns was slightly greater than in the previous month, and 22 per cent. greater than in November, 1918. It was reported, however, that a considerable amount of time was lost on account of shortage of railway wagons. At iron and shale mines employment continued good; at tin mines it was moderate; and at lead mines it varied from slack to good, according to locality. Apart from interruptions due to weather, quarrymen were well employed, except at china clay quarries, where employment was dull or bad. In the pig-iron industry employment continued good, on the whole, though below the level of November, 1918. At iron and steel works it was fairly good in general, but varied according to local circumstances, improving in some districts and falling off in others; a number of works were seriously affected by transport difficulties. In the engineering trades employment declined further as a result of the strike of ironmoulders, and there was much short time and unemployment. The state of employment in the shipbuilding trades showed considerable variation as between different centres, and on the whole may be described as fair. In the tin-plate trade employment, though hampered by shortage of wagons, was good, better than in October and much better than in November, 1918. In the other metal trades it ranged from fair to good, some short time being worked as a result of the ironmoulders' strike. Employment in the cotton trade continued fairly good in the spinning section and good in the weaving section. In the woollen and worsted, hosiery, jute and silk trades employment continued good. Employment continued good in the building, woodworking and furnishing, brick, cement, pottery and glass trades, though shortage of materials, attributed to railway delays, was frequently reported. There was some improvement in the paper, printing and bookbinding trades, and employment was good generally. The state of employment with dock and riverside labourers varied as between different ports; on the whole it was fairly good.

In regard to the variation in rates of wages reported above, the principal change was an increase of 5*s.* per week awarded to men employed in the engineering and shipbuilding industries, which was extended to men in various other metal trades and in the chemical and explosives trades. Workpeople in the woollen and worsted and the textile bleaching, dyeing, finishing, &c., trades also received further increases in wages under the operation of sliding scales depending on the cost of living, and there were numerous increases in the building and printing trades. Changes in hours of labour in November affected about 30,000 workpeople, whose recognised working time was reduced by an average of 3 hours per week.

At the annual supper and presentation of prizes in connection with the Rock Bowling Club, held last week in Dumbarton, several speakers touched upon present-day problems. Sir Archibald Denny said it had become the habit, or a catch phrase, to talk of the men as being slaves to the masters. That was never so in his memory, and was certainly not so under the system of mutual arrangements come to by the men, represented by the experienced members of the Works' Committees and the management. That seemed to him, however, to be the present condition between the unions and their members. Was it desirable or commendable, he asked, that during a strike, men who disagreed should only be able to work if they had moral and physical courage enough to pass through a lane of jeering fellow-citizens, and be escorted to homes in which they might find wife and children scared to death through intimidation of the meanest character? Colonel Denny, who followed, said it was at one time thought that, due to submarine action, it would be years before the world's shipping would be normal again. The best information he could gather did not seem to confirm that. One of their biggest shipowners had told him recently that, with American output, a few months would see the loss largely made up. Once upon a time, British shipbuilders were able to tempt owners either with cheap prices or quick delivery, or both. They could no longer do that. No one wanted the era of long hours and low wages to return. Short hours and high remuneration were ideal conditions, with one reservation—the man who paid must get full value for his money. A shipowner offered them some vessels the other day, but when he saw the price and learned that they could promise no definite delivery, he not only abandoned the idea of building, but abandoned the way of doing the trade he intended. He (Colonel Denny) had taken out the figures of his firm, audited by H.M. Treasury, for ten years pre-war (during the war 80 per cent. of all excess was taken by the Treasury, plus nearly 10*s.* in the £ on the balance, for taxation), and these figures divided among their several thousands of workers meant much less per week than many of their men earned in one hour.

FEDERATION OF BRITISH INDUSTRIES.—This Federation states that Mr. R. T. Nugent, its director, recently returned from a visit to the office of the Federation's Trade Commissioner in Madrid. He states in his report that the prestige of the federation there is hardly second even to that of the British Embassy. Representatives of British business houses in Spain also welcome the presence of the federation, as it is of great assistance to them and to the cause of British trade as a whole, for it forms a centre for British commercial interests in that country. Mr. G. H. Locock, assistant director of the Federation, who recently returned from Athens, reports that the exhibition of British manufactures there was a very great success.

THE NON-FERROUS MINING COMMITTEE.—The Non-Ferrous Mining Committee has begun its inquiry into lead and zinc mining. The views of the Lead and Zinc Mine Owners' Association were stated by Mr. Arthur L. Onslow, the chairman of the association, and by Mr. Anthony Wilson, vice-chairman. With regard to the mines producing galena only, they said that it would be impossible, with current working costs, to work at the prices for lead ruling throughout the summer, but that they saw no difficulty in carrying on the industry at the present market price for that metal. The mines producing blende only or both blende and galena were in a less hopeful position, owing to the impossibility of disposing of their blende except at unremunerative prices. It was stated that the withdrawal of the bonus on production and the cessation of the refund of the Coal Controller's awards now made it impossible to carry on zinc mining at a profit, and these witnesses were of the opinion that, at present costs, the mines would be unable to pay their way with a price for 50 per cent. blended of less than 12*l.* 10*s.* per ton. Mr. Wilson complained of the heavy burdens now borne by the industry in royalties, rates and taxes. He stated that the sliding scales for royalties, based on the price of the product, were fixed when working costs were much lower than they now are, and, consequently, there was a much greater margin between cost of production and selling price. The system of assessing for rates on the basis of the royalty charge, whether any profit were earned or not, now involved a heavy charge on the industry, not only on account of the increase in the basis of assessment, but also owing to the rapid rise in the rates themselves. Complaint was also made of unfair treatment by the income-tax authorities in the matter of allowances for depreciation and development work.

CONVEYOR INSTALLATION AT THE MAYPOLE MARGARINE FACTORY, SOUTHALL.

CONSTRUCTED BY MESSRS. W. AND C. PANTIN, ENGINEERS, LONDON.

(*For Description see opposite Page.*)

Fig. 34.

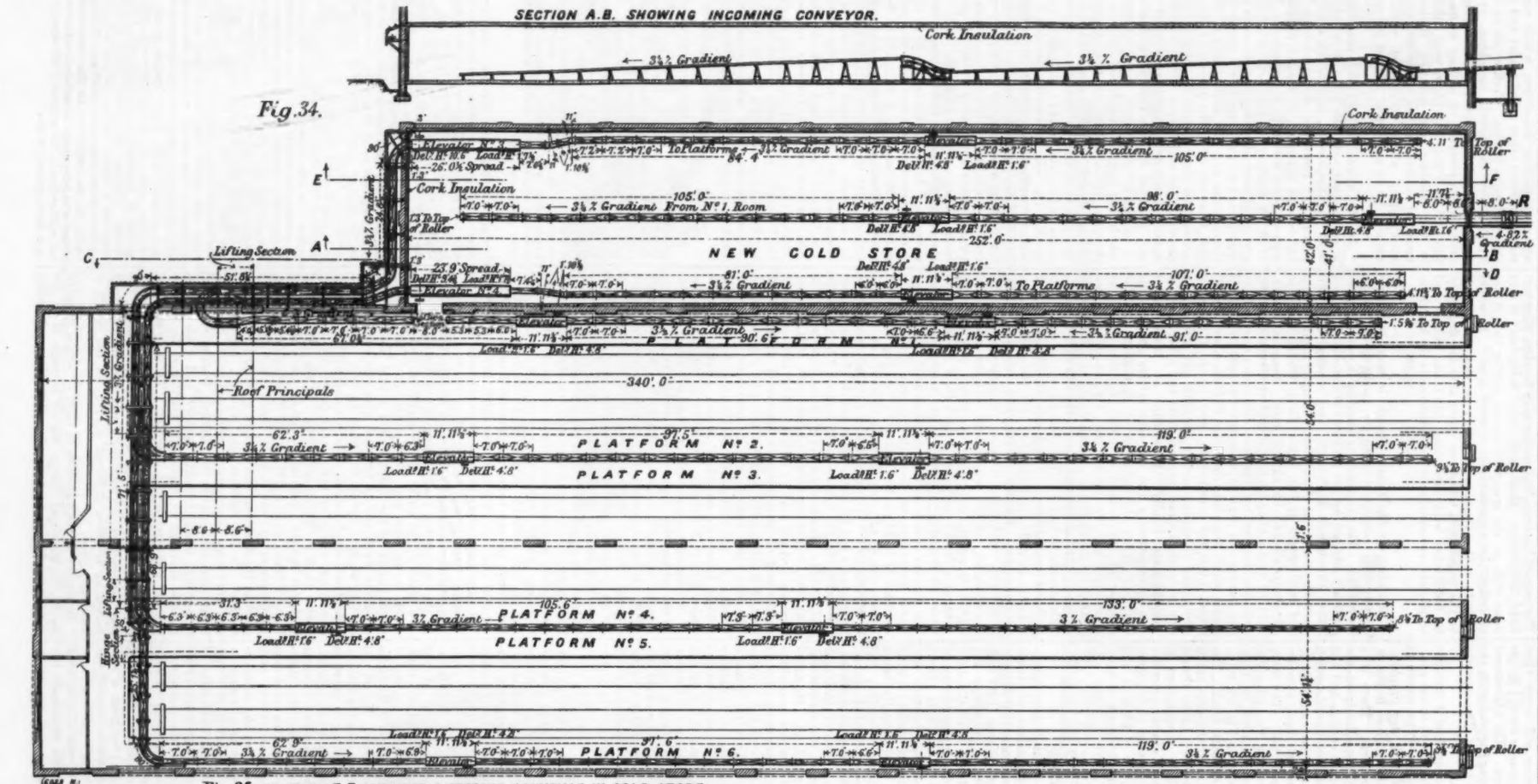
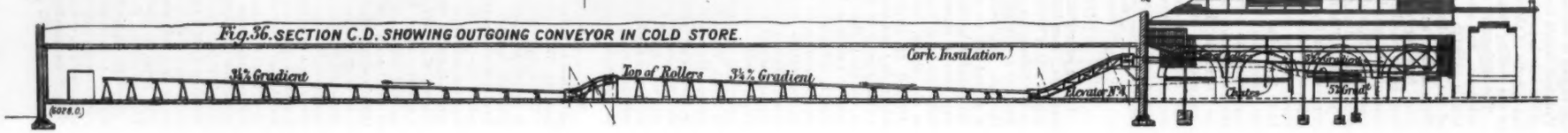


Fig. 35. SECTION E.F. SHOWING OUTGOING CONVEYOR IN COLD STORE.

Fig. 36. SECTION C.D. SHOWING OUTGOING CONVEYOR IN COLD STORE.



CONVEYOR INSTALLATION.

CONSTRUCTED BY MESSRS. W. AND C. PANTIN, ENGINEERS, LONDON.

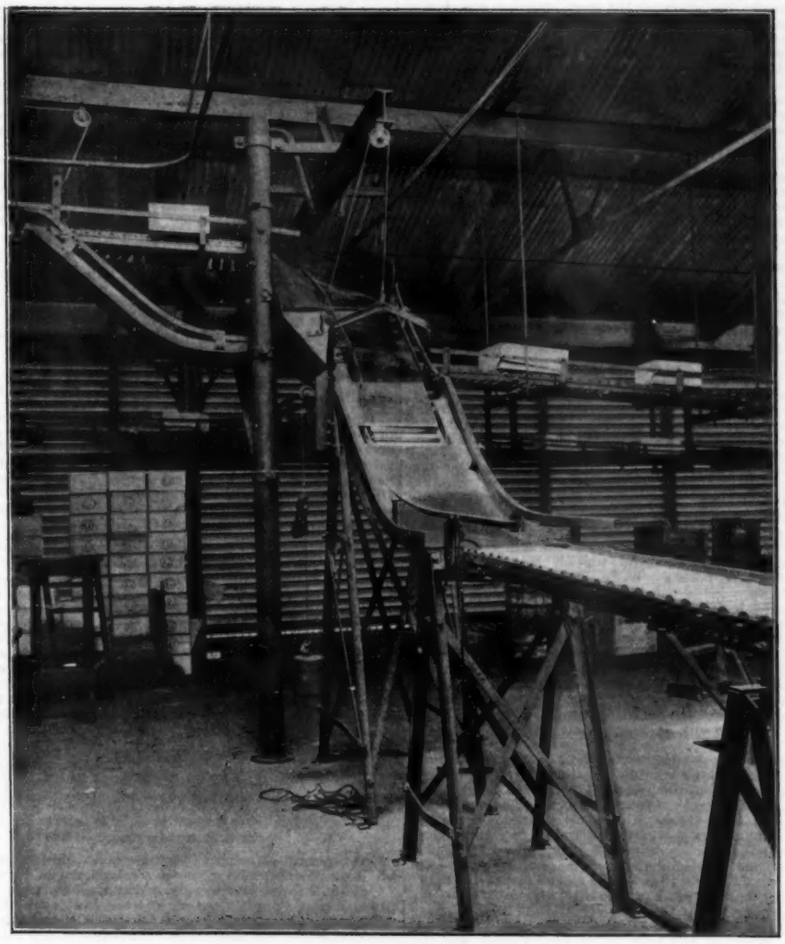


FIG. 37. RIGHT-ANGLE TURN-OUT ON GRAVITY CONVEYOR.

[CONVEYOR INSTALLATION AT THE MAYPOLE MARGARINE FACTORY.

By GEORGE F. ZIMMER, A.M.Inst.C.E.

(*Concluded from page* 782.)

THE long straight section of the conveyor, O P with set-off to Q, is shown in detail on Figs. 26 to 28, Plate XLVII. There are in this section two large elevators, Nos. 5 and 6. In order to reduce the number of supports, and therefore obstruction in the roadway, the conveyor is trussed between supports. By this means the stanchions are placed at from 20 ft. to 28 ft. centres. This section is outside the buildings, and is therefore provided with a light cover throughout the length, and small enclosures are provided for the protection of the mechanisms and motor drives of the elevators. The section P Q is carried over the railway siding on trestles at a height of about 22 ft. above datum level.

Figs. 29 to 33, Plate XLVII, show the section Q R. This is therefore a continuation of the length shown in Figs. 26 to 28, and completes the run to the new cold store building U. The details for supporting and protecting the plant are similar to those for sections O, P, Q. The distance from O through P, Q to R is about 840 ft.

The arrangements for working the new cold store inwards and outwards are shown on the opposite page. The lay-out of the conveyors, elevators and humpers is very complete and can be easily followed. The method employed for diverting the boxes from the main conveyor at the end of the despatch platforms on to the conveyors running down the platforms is made clear by reference to Fig. 38, page 858. One roller section is lifted up in order that the boxes may run down the chute and round the bend to the conveyor along the platform. Fig. 39, on page 858, shows the conveyor and two humpers along one of the despatch platforms. The men who load the trucks push a wooden wedge between two of the rollers of the conveyor opposite the truck they are loading, or a piece of sheet metal bent to cover two rollers may be employed. Either method brings the boxes to a standstill.

Fig. 37 above shows a special right-angle chute used for delivering the boxes from a straight-through conveyor on to a conveyor at right angles to it.

The labour-saving devices in this plant are practically confined to gravity conveyors and the necessary accessories for renewing the gradient from time to time. With a gravity conveyor, if a breakdown occurs, the cases merely accumulate and fill up the conveyor, whereas with the positive or mechanically-driven conveyor a stoppage would be the result, and if the driving gear were at a remote end, say, 200 ft. away, much time might be lost in communicating with the attendants at the far end, which might result in the boxes being damaged before the power could be shut off. Gravity conveyors act as an accumulator throughout all handling operations, so that if, for instance, the box-making machines are all at work and producing at full speed, the conveyor may be full of boxes from end to end. They may even be packed on top of each other or the smaller ones placed inside the larger.

When the boxes are placed on gravity runways at regular intervals—for instance, at 3 ft. spacing—they will gradually close up and get nearer each other, and eventually touch. This is due to the preceding cases energising the rolls, which helps the succeeding ones to travel a little faster. The first case, finding the rolls stationary, naturally travels more slowly.

The law of gravity was formulated by an illustrious Briton in 1688, and the development of the foremost gravity handling device may also be claimed as a British invention. Although we may rightly say that the gravity carrier in its present form is one of the legacies of the Great War, it has been used sporadically in more primitive form in this country for quite a long time.

As early as 1832 it was employed in the Naval Biscuit Bakery at Portsmouth for returning the empty dough-boards to the mixing machines. The credit of perfecting gravity rollers with ball bearings is, however, due to American engineers, who were the first to use them extensively. As recently as ten years ago these machines were only rarely used except in very short lengths—say, a foot or two—such, for instance, as those employed in front of elevators and lifts for the purpose of feeding and withdrawing packages quickly and with little effort. Gravity conveyors of the roller type were viewed with mistrust as a kind of mechanical makeshift only fit for amateur work. As a matter of fact, the device was, and is, the simplest possible. So much was this the case that when an official in a high position in the War Department was first approached by one of the principal makers of these devices with the object of employing them for the handling of munitions he said they had no use for them. Before the war was ended, however, the same firm had supplied close upon 40 miles of these conveyors for purposes more or less directly connected with war work. They turned them out at the rate of 1,000 ft. per week, not to mention the records of other firms of equal importance.

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, the 17th inst., in the Society's Rooms, 70, Victoria-street, Westminster, Sir Napier Shaw, F.R.S., president, in the chair.

A paper by Mr. F. J. W. Whipple, M.A., entitled "*The Laws of Approach to the Geostrophic Wind*," was read. The mode of transition from the winds near the surface of the earth to the general current at moderate heights has been discussed by various authors. In this paper stress was laid on the geometrical aspect of the question. The term "relative wind velocity" being used for the velocity which must be combined with the geostrophic wind velocity by vector addition to give the actual wind velocity at any level, the laws of approach to the geostrophic wind are: (1) The relative wind turns uniformly with increasing height; (2) the relative wind decreases with increasing height according to the exponential law; (3) the actual wind at the surface and the relative wind there are inclined at 135 deg. The modification of the "laws" when departures from the ideally simple conditions they pre-suppose are allowed for was discussed.

Mr. G. M. B. Dobson, M.A., also read a paper on "*Winds and Temperature Gradients in the Stratosphere.*" From the results of temperature observations by "ballon sondes" it can be shown that the horizontal pressure gradient and therefore the wind velocity should decrease rapidly on passing from the troposphere to the stratosphere. Previously there had been little confirmation of this by actual observations. Seventy ascents recorded by the International Commission gave data for temperature, wind velocity and wind direction to great heights. These showed that almost without exception, winds of moderate or great velocity in the troposphere, fall off very rapidly on entering the stratosphere, while the wind direction remained constant. On days with small pressure gradients this effect was not usually found; a result which was to be expected, since the slope of the tropopaus would then not necessarily be towards the low pressure. Horizontal pressure and temperature gradients calculated for the observed winds on typical days with moderate or large pressure gradients, show that the pressure gradient is suddenly reduced, and the temperature gradient suddenly reversed, on entering the stratosphere. The temperature gradients calculated from the observed wind velocities were in good agreement with those deduced by Mr. W. H. Dines from temperature and pressure observations.

A third paper was by Captain C. J. P. Cave, entitled "*Quotations from the Diary of Samuel Pepys on the Weather.*" In this the author had collected together all references to the weather from the Diary using for this purpose Wheatley's edition. These amounted to as many as 557 entries and were arranged in chronological order. They formed a brief comment on the general weather conditions prevailing from January, 1660, to May, 1669. In a preliminary essay the author summarised the principal weather events for each year. He pointed out that Pepys could not claim to be considered as a meteorologist, and that his references to the weather were such as any one might make in a diary or in correspondence. He also stated that Pepys' memory for meteorological events was not always good, and his remarks on the worst or best weather he remembered must be taken with caution.

LIMITED LIABILITY COMPANIES.—A booklet under this title has been issued, at the price of 1s. net, by Mr. Joseph Morgan, technical expert in the formation, management and winding-up of joint stock companies, of 10, Lower John-street, Regent-street, W. 1. It contains in a concise form much useful information regarding the formation and the working of limited liability companies.

PRECISE LEVELLING.*

By Major Ernst Olaf Henrici, R.E., Assoc.Inst.C.E.

When the heights of the original bench marks of the Ordnance Survey were first determined, it was considered that the work done would stand good for an indefinite period, and that all that would be required on revision would be to replace such bench marks as had disappeared, except in mining districts where it was known that subsidences were liable to occur. Experience has shown, however, that many of the marks have altered their heights to a greater or less extent, either from subsidence of the structures on which they had been cut, or by actual displacement. Also a considerable number of marks have disappeared. It is consequently becoming increasingly difficult to distribute the inevitable errors of the secondary levelling, and to prevent their accumulation.

It was decided in 1911 to undertake the levelling of an entirely new network, to form the basis for the heights shown on the maps, and at the same time to study more thoroughly the height of mean sea-level.

There seems to have been very little advance in the practice of spirit levelling in this country for many years, and in consequence a study of progress made in other countries was carried out, and levels of various patterns were experimented with before the methods to be adopted were finally decided on.

The methods and instruments decided on are described in the paper, and also the patterns of bench marks used.

The new lines are laid out so that it is possible to erect at intervals of about 25 miles special "fundamental" bench marks. These marks are confined to sites where the presence of rock within reasonable distance from the surface, makes it possible for the mark to be either fixed in the living rock, or in concrete founded on the rock. Sites are avoided where the marks are likely to be disturbed by mining or quarrying. These marks have three reference points, one consisting of a metal bolt let into the top of a granite pillar, for general use, and two lower marks which are buried, and are for the use of the survey only, for the purpose of checking the height of the upper mark in time to come. Intermediate marks are of a special form of gun-metal plate let into the surface of walls.

The "probable error" of the difference in height between any two consecutive "fundamental" marks is about 0·01 ft., *i.e.*, it is an even chance whether the actual error is greater or less than this amount, and it is very improbable that the error will be as much as three times this amount.

The intermediate marks cannot be relied on to hold their height to the same extent as the fundamental marks, as it is impossible to avoid passing over ground that is liable to subsidence due to mining operations or to movements such as are caused by the varying moisture content of the soil in alluvial or fen districts, or to avoid the possibility of direct subsidence of the structures on which the marks are placed.

The completion of the work has been delayed by the war, but pending the publication of the results, information required by engineers can be obtained, if available, from the Director-General of the Ordnance Survey, Southampton.

The paper contains an investigation into the causes of errors in levelling operations, an account of the methods adopted to minimise them, and an estimate of their magnitudes. Tables are given showing how far the actual discrepancies obtained agree with those to be expected from the estimated effect of the various individual errors considered. The chief conclusions arrived at are: (1) The design of the standard levelling instruments as used in this country for many years can be considerably improved, not only for precise work, but for all work. The instrument used in the work, discussed in the paper, is one designed by Dr. Wild (formerly of the Swiss survey), and made by Messrs. Zeiss, of Jena. The author is glad to say that firms in this country are now producing instruments embodying the good points of the Zeiss instrument; (2) the chief cause of error in the levelling as now carried out is due to the movements of the supports of the levelling staves during the time they are "holding the height" between the forward and back readings to the staff.

The paper was in preparation, and largely written, when the outbreak of war severed the author's connection with the Ordnance Survey. The paper was completed in 1917, and the results up to that date were kindly placed at the author's disposal by the Director-General. The author has no knowledge of the later work.

Wiring Rules—The Council of the Institution of Electrical Engineers have approved the following recommendation of the Wiring Rules Committee: "That Wiring Rule 39 be amended to read as follows: 39. Except for wiring fittings, the cross-sectional area (table, column 2) of any copper conductor must not be less than 0·0015 sq. in. (1/·044 in). The cross-sectional area of fittings wires must not be less than 0·0010 sq. in. (1/·036 in.)" The matter is one of importance in view of the introduction of the new standard sizes and the question has been raised in correspondence with the Institution and in the Press. A complete revision of the wiring rules is in hand, and the committee will be glad to receive suggestions (in the form of specific amendments) for consideration during the revision. Suggestions should be addressed to the Secretary of the Institution, 1, Albemarle-street, London, W. 1. Many valuable suggestions have already been received.

* Abstract of a paper read at the ordinary meeting of the Institution of Civil Engineers, on Tuesday, December 16, 1919.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Except in the engineering trade, where matters are going from bad to worse as a result of the moulders' strike, there has been such a marked improvement in industrial activity that materially increased prosperity is promised for the new year. Practically the whole of the steel branches are sharing in the benefit which has accrued from the recent big influx of orders from the Colonies and foreign countries for mild steels and tools. Owing to the handicap placed on competitive output by recurrent labour troubles, the demand for Sheffield materials promises to reach record proportions. Prices of raw materials are again on the up-grade, and the revised railway rates are likely further to increase selling prices. But the bulk of foreign buyers seem to be in urgent need of deliveries and show little hesitation in entering into contracts at rates highly remunerative to local steel makers. Makers of railway axles, tyres and springs are carrying over a large volume of work to the new year This is due to the greatly increased requirements of home, Colonial and South American railways. India is a big buyer. The condition of exchange in America is also exceptionally favourable to local makers of special steels. This is having a pronounced effect on American purchases of high-speed steel. The lighter trades are all engaged at high pressure. Export business in files and saws is particularly brisk.

South Yorkshire Coal Trade.—The position in the house coal trade leaves very much to be desired both from the point of view of merchants and consumers. Deliveries are coming forward very badly from local collieries, which, however, are largely handicapped owing to the continued shortage of trucks. On several days during the past week production has compulsorily been restricted owing to the absence of empty wagons and the limitation of stocking facilities. Merchants will carry over big arrears to the new year. By dint of careful economy manufacturers, railway companies, electricity and gas concerns have managed to augment reserves against the holiday stoppage, but stocks at many of the iron and steel works are still much below the normal. The demand for all classes of manufacturing fuel, both for home use and for shipment, is considerably in excess of the supply. Quotations:—Best branch hand-picked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty slacks, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

British Production of Pig-Iron and Steel Ingots.—The National Federation of Iron and Steel Manufacturers, Temple Bar House, 23 to 28, Fleet-street, E.C. 4, have issued the following figures. The production of pig-iron in the United Kingdom for the eleven months of 1919, amounted to 6,730,000 tons; it amounted to 9,072,000 tons for the whole of 1918 and to 10,260,000 tons for the whole of 1913. The production of steel ingots was 7,200,000 tons for the eleven months of 1919; 9,591,000 tons in 1913 and 7,664,000 tons in 1913.

H.M.S. "Tyrian."—The torpedo-boat destroyer Tyrian, designed and built by Messrs. Yarrow and Co. Limited, Scotstoun, Glasgow, ran her trial trip on the 16th inst. This is the last of a series of 29 destroyers built by the firm since the beginning of the war. The Tyrian is 273 ft. long and has a fully-loaded displacement of 1,060 tons; she is fitted with turbine machinery, steam being supplied by the latest type of oil-burning Yarrow water-tube boilers with Yarrow's patent superheater. The Tyrian obtained a speed of over 45 miles an hour (practically 40 knots) on an Admiralty 4 hours' official trial in deep water. This is the highest official speed ever maintained by any warship in the world, and is a result of the large amount of experimental and research work carried out by Messrs. Yarrow, who have specialised in the design of construction of high-speed vessels.

X-Ray Frequencies.—In the analysis of characteristic X-ray spectra four different kinds of vibration are associated with each series of lines. In the K series of a chemical element there are, for example: (*a*) Several emission frequencies; (*b*) one critical absorption frequency; (*c*) one critical ionisation frequency; (*d*) one frequency ν such that the product of $h\nu$ represents, on the quantum theory, the minimum energy which the electron in the X-ray tube must have in order to be able to produce the K series. It is known that the highest frequency (*a*) in the emission spectrum (that of the γ line) and the three other frequencies (*b*), (*c*), (*d*), are practically equal to one another. The object of a recent research which G. William Duane and Kang-Fuh Hu brought before the American Physical Society (*Physical Review*, vol. xiv., pages 369 to 375, October, 1919) was to ascertain how far that equality holds. The question is of importance for the theories of the mechanism of X-radiation and of the structure of the atom. The apparatus used were Coolidge tubes, with targets of tungsten or of rhodium, worked generally at the moderately high potential of 37,750 volts by currents from accumulators; an amethyl iodide ionisation chamber; a layer of potassium iodide as absorber; the X-ray spectrometer of which Duane and Blake had made use in their determination of Planck's constant h, and calcite crystals. The result of the experiments was that the critical frequencies are all the same within less than 1 per cent.; frequency (*b*) and (*c*) agreed within 0·1 per cent., the agreement with (*d*) was within ½ per cent.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—For the time being there is nothing at all doing in Cleveland pig-iron. Certainly deliveries are going forward under current contracts as transport facilities become available, but there is no new business passing, producers, in view of confident anticipation of immediate advances, refusing to sell, so that up to the present the position is that prices are unchanged but purely nominal. The truck situation is stated to be slightly better, but the shortage is still very pronounced. Inquiries for pig-iron from abroad continue on a heavy scale, but competition for such orders is apprehended, and doubt is expressed as to whether foreign buyers will still be keen to place orders here at further advanced rates. With rather more tonnage coming forward, exports have shown some improvement of late. For home cosumption No. 1 Cleveland pig-iron is 167*s.* 6*d.* and No. 3 g.m.b. and all commoner qualities of iron are 160*s.*; and, for despatch to foreign ports, quotations are 172*s.* 6*d.* and 165*s.* respectively.

Hematite Iron.—Conditions in the East Coast hematite branch are very similar to those that characterise Cleveland pig-iron. Though prices are not quotably changed, makers will not sell, except on terms which cover them against expected rise, and as buyers hesitate to make contracts on such an uncertain basis, business is practically at a standstill. No. 1 remains at 202*s.* 6*d.* for home use, and 207*s.* 6*d.* for shipment abroad, and mixed Nos. are put at 200*s.* for home purposes, and 205*s.* for export.

Foreign Ore.—There are now a good many inquiries in the market for foreign ore, and it would appear that once more buyers have held off rather too long. It is rather difficult definitely to fix quotations, but they have certainly been stiffened by advancing freights. On the basis of the Bilbao-Middlesbrough freight of 27*s.*, the ex-ship Tees price of best rubio cannot be put under 53*s.*

Manufactured Iron and Steel.—Customers are clamouring for nearly all descriptions of finished iron and steel. So full of work are manufacturers that they are having to refuse orders on both home and foreign account. Rising prices have no apparent check on buyers. Demand is most pronounced for ship plates and galvanised sheets. Few firms are in a position to quote for export. Home customers would readily give more than the following recognised market rates for anything like early delivery:—Common iron bars, 22*l.* 10*s.* to 23*l.*; marked bars, 25*l.* 10*s.*; steel plates, 18*l.* 15*s.*; steel angles, 18*l.* 5*s.*; steel joists, 18*l.* 5*s.*; heavy sections of steel rails, 17*l.* 10*s.*; black sheets, 30*l.*; and galvanised sheets, 40*l.*

Coke.—The expected rise in coke has not yet occurred. Scarcity is still very pronounced and essential local needs are difficult to meet. Medium blast-furnace kind is still 48*s.* at the ovens, and low phosphorus sort remains at 50*s.* 6*d.* at the ovens.

Contracts.—Messrs. Clayton and Shuttleworth, Limited, Lincoln, have recently received orders for four "Clayton" 5-ton end-tipping steam wagons, from the North Riding County Council, and one from each of the following: Chesterfield Rural District Council, Eston Urban District Council, West Hartlepool Corporation, and Westmorland County Council.

Personal.—Mr. A. B. Mallinson, M.I.Mech.E., who for eight years has been associated—as consulting and chief engineer—with the group of paper mills comprising: Messrs. Charles Marsden and Sons, Limited; the Donside Paper Company, Limited; the Irish Paper Mills Company, Limited; John Allen and Sons (Ivybridge), Limited; is severing his connection with these mills, and from January 1 onwards will practice as a consulting engineer, specialising in paper mill and works power equipments generally, from his old address: Worsley-street, Salford, Lancs.

Solubility of the Rare Gases.—The solubility of the rare gases in water and some other solvents was studied by Ramsay and his collaborators soon after their discovery, and was found to be low, though not exceptionally so. One of the later investigators of this problem at University College, London, was Andreas von Antropoff, who, resuming these studies subsequently at Riga, with improved apparatus, recently published the results of his research in the *Zeitschrift für Elektrochemie*, 1919, pages 269 to 297. The apparatus comprised a Toepler mercury pump, various pipettes and devices for introducing the gas and for depriving liquids of their gases, and new apparatus for determining the solubility. In agreement with Ehmcke he finds that helium is of all gases known the least soluble in water, 1 gramme of water at 20 deg. C. taking up only 0·00996 cub. cm. of helium (reduced to normal temperature and pressure), against 0·0185 cub. cm. of hydrogen at 22·5 deg. The singular peculiarity of helium is that the solubility slightly increased as the temperature was raised, to 0·0108 at 50 deg., whilst in all the other cases the solubility of a rare gas in water fell off decidedly when the temperature was raised. Antropoff's value for the solubility of helium is lower than that of Ehmcke. The solubilities of the other gases in water were, at 20 deg. C.: neon, 0·0147; argon, 0·0374; krypton, 0·0626, xenon, 0·1123; radium emanation, 0·238. In aniline xenon was much more soluble than in water, the figure being 0·501; glacial acetic acid also dissolved it more readily.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—During the past week there has been a very pressing demand for steel, and it is doubtful if such great pressure was ever exceeded in the Scotch steel trade. Certainly we have had spells when a very heavy demand existed, but at the present time nearly all users of steel seem to be in the market at the one time, and as the general trade of the country is good everybody is trying to meet the demand in his own line and the consumption of steel, therefore, amounts to a very large tonnage. Alterations and extensions which were impossible during the war period have all come on at the one time, and the output of steel material is scarcely equal to the present demands. The shipyards are getting through a heavy tonnage of plates, &c., and mills are being kept going at top speed. Boiler plates are also in much request and sectional material is selling freely. Export business is forming a very small amount at the present time owing to the home requirements, and some handsome premiums have been offered to secure lots for overseas markets. The makers of black sheets report no falling-off in demand despite the recent increases in prices, and it would seem as if the higher quotations only acted as a stimulus to buying, so eager are consumers to cover their requirements. The export trade is also very good and recent business has included fair quantities for shipment to India and Australia, as well as other parts, South America being also a good buyer. In the case of galvanised sheets it cannot be said that they are in such good demand as buyers are evidently not inclined to pay the high figure now quoted. It is freely said, however, that it may be necessary to maintain present quotations in the meantime as costs of production show no signs of easing off.

Malleable Iron Trade.—The home demand experienced by the malleable iron makers in the West of Scotland continues on a very large scale, and quite satisfactory business has been booked since the latest advance in prices. The quantity being turned out just now is quickly absorbed, and some consumers keep on pressing for supplies. Mills are running steadily and deliveries are being speeded-up owing to the near approach of the holidays. Everything possible will be sent out before the works close down at the end of the year. The home trade is taking up most of the present output, but a certain amount is finding its way abroad even at the high prices now demanded.

Scotch Pig-Iron Trade.—A strong tone prevails in the Scotch pig-iron trade and makers are all being kept well employed. The demand is good, and especially is that the case for hematite which is being largely bought at full prices. The latter are firm and unchanged, but an advance is highly probable in all classes of iron in the near future; in fact for export lots of certain brands higher values are now being named. The shipping demand is again better, and some good inquiries are reported, the tonnage being fairly large. Forge iron shows no change over the week, but foundry iron is a trifle more plentiful, but there is a ready outlet for whatever is available.

Engineering.—The various engineering firms throughout the country are all very busy at the present time, and order books are well filled up for months to come. A great deal of the machinery under construction is for shipment abroad, but home requirements are never overlooked, and wherever possible a little preference is being given. Work has been carried on so strenuously of late that the forthcoming holidays are being looked forward to with no small amount of pleasure, and the short breathing space of a week or ten days is eagerly anticipated by the staffs as well as the workers. The recent demands have been for almost all classes of machines, which, in the West of Scotland area, means a very wide range. Costs overall are very high, and the finished article is naturally very much dearer than it was a few years ago.

RAILWAY ELECTRIFICATION IN SOUTH AFRICA.—We read in *The South African Mining and Engineering Journal*, that in a speech at the annual dinner of the South African Institution of Electrical Engineers, the Minister of Railways pointed out that South Africa was six years overdue with new railway construction. The time had come when the most urgent necessity, had to be faced of embarking upon a scheme of new railway construction. It was a truism to say that the country could not be developed as it should be unless the necessary means of communication were provided, and he would tell the members then present that in the mind of the Government it was necessary that when a new scheme of railway construction was introduced it should not be an ordinary hum-drum Railway Bill, such as those in the past, but they should have a bold and comprehensive scheme of railway construction. Regarding the electrification of the railways, Mr. Burton mentioned the opinion of Mr. Merz, who had stated that he knew of hardly any country which was so favourably situated with regard to the electrification of its railways as South Africa. It was the intention of the Government to carry out the recommendations made by Mr. Merz at the earliest possible opportunity, and, added the Minister, he trusted that one of the results would be—perhaps it would be only one of the minor results—that there would not be so many complaints about the shortage of trucks between Johannesburg and Durban. He thought that when the electrification was carried out the change which would be brought about would be revolutionary. It would in most cases double their carrying power, and would have a most beneficial effect on the country.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Market.—With the near approach of the holidays business has been restricted. A lightning strike of men at the hydraulic power station at Newport, and in consequence a cessation of loading and unloading operations at the docks for 24 hours, dislocated the arrangements of exporters and also led to temporary stoppages at a number of Monmouthshire pits, because of a shortage of empty wagons. The strike, fortunately, was quickly settled, the men being conceded time and a half for Sunday work, and operations at the docks were resumed after a 24 hours' stoppage. The action of the authorities in giving preference in loading to British vessels bound to home ports with coal cargoes, for the purpose of accumulating stocks for industrial requirements and bunkering purposes over the holiday period, has also dislocated private arrangements. Other vessels loading for foreign countries have been turned out of berth to provide accommodation for steamers "directed" to the coasting trade, and it is inevitable that a large quantity of shipping will be detained over the holidays as tipping facilities are inefficient to cope with exporters' requirements. At present it is necessary to secure licences before shipment can be made, but from January 1 next it will only be necessary to obtain the sanction of the local representative of the Coal Controller to shipment before a Customs pre-entry will be granted. Available supplies of coal are exceedingly scarce, and for the odd parcels obtainable record prices are asked and paid. Inquiries principally are for odd lots to finish off the loading and bunkering of vessels, likely to get away immediately before or subsequent to the Christmas vacation. For best Admiralty large as high as 110*s.* per ton has been paid for January shipment, with the price for prompt loading from 100*s.* to 105*s.* Leading Monmouthshire large coals are round 100*s.*, and drys from 92*s.* 6*d.* to 97*s.* 6*d.* Steam smalls are also scarce and worth up to 82*s.* 6*d.* for the best sorts, with ordinaries from 70*s.* up. The Mining Association of Great Britain has been requested to appoint a committee to advise the Coal Mines Department of the Board of Trade as to what alterations are necessary or desirable in the present arrangements governing the pit-head prices chargeable for coal for inland consumption in order to place each description of fuel on an economic basis. Exports of coal to foreign countries from South Wales last week amounted to 350,214 tons, of which 199,771 tons were from Cardiff, 73,089 tons from Newport, 43,795 tons from Swansea and 33,559 tons from Port Talbot.

SILICA REFRACTORIES.—The huge development of the last few years in silica refractories for by-product coke ovens and metallurgical furnaces has induced the United States Bureau of Standards to issue a further publication on Silica Refractories and Their Tests. This report, Technologic Paper No. 116, drawn up by Donald W. Ross, is a pamphlet of 84 pages, dealing in general terms also with the geology of the quartzite used and its treatment. The chief source is the Medina quartzite (ganister) from Pennsylvania, and some information is given on the manufacture of silica bricks in the Harbison and Walker works. In testing the material, 2-in. cubes are made of ganister mixed with 2 per cent. of lime, and the cubes are dried at 110 deg. C. and then burned at temperatures, rising in steps of 50 deg., from 1,150 deg. to 1,500 deg. C. The density and porosity are determined by taking the weight dry, wet, and suspended in liquid; for the wet saturation test the specimen is placed in an iron cylinder and covered with hot water, over which a vacuum of 24 in. of mercury is maintained for 4 hours; in the case of the unburned raw material the wet and suspended tests are made in petroleum. The accepted specific gravities of the constituents are: Quartz 2·650, cristobalite 2·333, tridymite 2·270; the gravity of the burned brick should fall within these limits; the density of a brick affords an indication of the degree of burning it has undergone. To ensure uniformity the quartzite should be crushed in a dry pan, screened, mixed in a concrete mixer without further crushing, and be moulded by machinery at a pressure of 1,500 lb. per square inch. In burning the solid volume increases by 10 per cent. to 15 per cent.; as the average porosity amounts to 26 per cent., however, the exterior volume expansion exceeds the solid expansion, and the expansion cannot be expressed by a single coefficient. To produce a brick of low porosity and low specific gravity the temperature should gradually be raised to 1,250 deg., held between that and 1,350 deg. for several days (to facilitate the transformation and the soaking) and afterwards further be raised to cone 18 or 20; the percentage in tridymite will then be high. Most commercial bricks are largely crystobalite and tend to spall chiefly between 220 deg. and 275 deg. when the α crystobalite passes into the β modification while strongly expanding. The value of the bricks much depends upon the degree of bonding of the quartz grains. Further experiments are to be made on the cross-breaking strength and hot-crushing strength at temperatures up to 1,500 deg. and 1,600 deg. C.; so far load tests have not been pushed beyond 1,400 deg. C. We should add that according to C. N. Fenner (of the Geophysical Laboratory, Washington), one of the collaborators in this research, cristobalite (not tridymite) is the stable high-temperature form of quartz. This statement does not appear to be in harmony with the summary of the report, and contradicts Rees, Le Chatelier and others; but it was recently reasserted by Fenner in the Journal of the Society of Glass Technology (1919, pages 116 to 125) and was confirmed last year by J. N. Ferguson and H. E. Merwin (*American Journal of Science*, 46, pages 417 to 426), who found that tridymite melts at 1,670 deg. and cristobalite only at 1,710 deg.

NOTICES OF MEETINGS.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Christmas Lectures on "The World of Sound," by Professor W. H. Bragg, C.B.E., D.Sc., F.R.S., Quain Professor of Physics, University of London. Tuesday, December 31, (I) "What is Sound? Thursday, January 1, (II) "Sound and Music."

THE ROYAL SOCIETY OF ARTS.—Friday, January 2, at 4.30 p.m., at John-street, Adelphi. Indian Section. Mr. A. P. Morris, B.Sc., Provincial Art Officer, Burma, "Burmese Village Industries; Their Present State and possible Development." Sir Harry Adamson, K.C.S.I., M.A., LL.D., Lieutenant-Governor of Burma, 1910–15, will preside.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 2, 1920, at 7.30 p.m., meeting at 39, Victoria, street, Westminster, S.W. 1. Lecturette, "Automatic Electric Weighing Machines, as used with Machine Packers," by Mr. A. V. Sims, Associate Member.

BLOW LAMPS.—The manufacture of blow lamps, brazing outfits and oil stoves has long been known to have been largely in the hands of Continental nations, including Germany, in pre-war times, and when the war started both the British and French Governments found that they had been dependent upon the importations of these goods for many years. The Government, therefore, approached certain British firms with a view of supplying these goods, and one of the first to respond to the call was the Kitson Empire Lighting Company, Limited, of Stamford, Lincolnshire, who have devoted a considerable portion of their extensive works to the manufacture of these goods. These vapour-burning devices originated from the inventions of Mr. Arthur Kitson when a resident in the United States. The first commercial oil-burning lamp both for heating and lighting was designed by Mr. Kitson, and both the Germans and the Swedes were not slow in recognising the value of these inventions.

THE GOVERNMENT AND RAILWAY TRANSPORT.—*Apropos* of our leading article in our issue of last week (page 825 *ante*) we learn that the Advisory Committee on Railway Rates and Demurrage have presented their reports to the Minister of Transport. The report on rates is now being considered by the Minister, and it is hoped that his directions will be ready and issued at an early date. With regard to demurrage the Advisory Committee have made certain recommendations to the Minister, which he has accepted. As from January 1, the revised charges for demurrage on ordinary wagons will be 3*s.* per day for the first two days' detention after the free period and 5*s.* for each later day. The present charge is 1*s.* 6*d.* per day. It is complained that there has been a growing tendency of traders to detain wagons. Between January and June inclusive the demurrage incurred was 31,975*l.* per month, representing a detention of 426,338 wagon days per month, as compared with 23,522*l.* per month between November, 1917, and October, 1918, or 313,624 wagon days per month. The position in 1919 therefore was 36 per cent. worse than in 1918, From September, 1913, to August, 1914, inclusive, demurrage incurred averaged 12,972*l.* per month, representing 172,960 wagon days. In this period an extra day was allowed both for loading and unloading at private sidings, docks and wharves, but even after making allowance for this it is evident the present position is considerably worse than it was before the war—as was pointed out in our article. A detailed statement for last September shows that 15 per cent. of the demurrage was incurred before conveyance, and 85 per cent. after conveyance.

THE MICROSCOPE: ITS DESIGN, CONSTRUCTION, AND APPLICATION.—The Faraday Society, the Royal Microscopical Society, the Optical Society and the Photomicrographic Society, in co-operation with the Optical Committee of the British Science Guild, meeting in joint session, will hold a symposium and general discussion on "The Microscope: Its Design, Construction and Application," on Wednesday, January 14, 1920. The meeting will be held in the rooms of the Royal Society, Burlington House, Piccadilly, W. 1 (by kind permission of the president and council), and it will extend over two sessions: from 4.30 to 6.30, and from 8 to 10 p.m. During the afternoon preceding the meeting, from 2.30 to 4.30, an exhibition will be held in the library of the Royal Society, which will illustrate recent developments in the science of microscopy and the latest applications of the microscope in all branches of industry. The purposes of the discussion are: (1) To stimulate the study of and research in microscopical science in the United Kingdom by—(*a*) indicating lines of progress in the mechanical and optical design of the instrument; (*b*) showing by means of exhibits, recent improvements in the microscope and its technique; and (*c*) the varied uses to which the microscope can be applied as an instrument of research in the sciences, arts and industries. (2) To encourage the manufacture in this country of the highest class of instrument and of the optical glass required for that purpose. The meeting will be presided over by Sir Robert Hadfield, Bart., D.Sc., D.Met., F.R.S., President of the Faraday Society, who will deliver an opening address, and Mr. J. E. Barnard, President of the Royal Microscopical Society, will then give a general survey of the subject, and he will be followed by Sir Herbert Jackson, K.B.E., F.R.S. Professor F. C. Cheshire, C.B.E., will then speak on the mechanical design of microscopes, and a paper by Professor A. E. Conrady, on "Microscopical Optics," will be presented.

CONVEYOR INSTALLATION AT THE MAYPOLE MARGARINE FACTORY, SOUTHALL.

CONSTRUCTED BY MESSRS. W. AND C. PANTIN, ENGINEERS, LONDON.

(*For Description see Page* 855.)

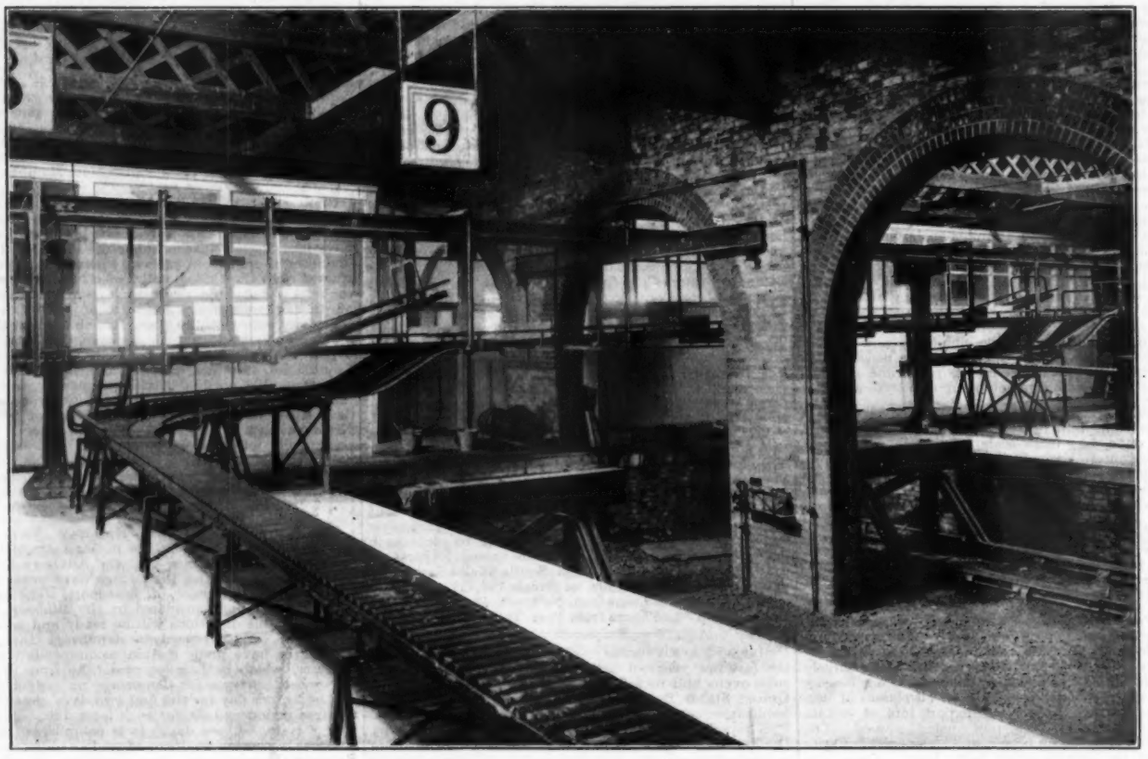


Fig. 38. Drawbridge Trap for Feeding the Loading Platform Conveyors.

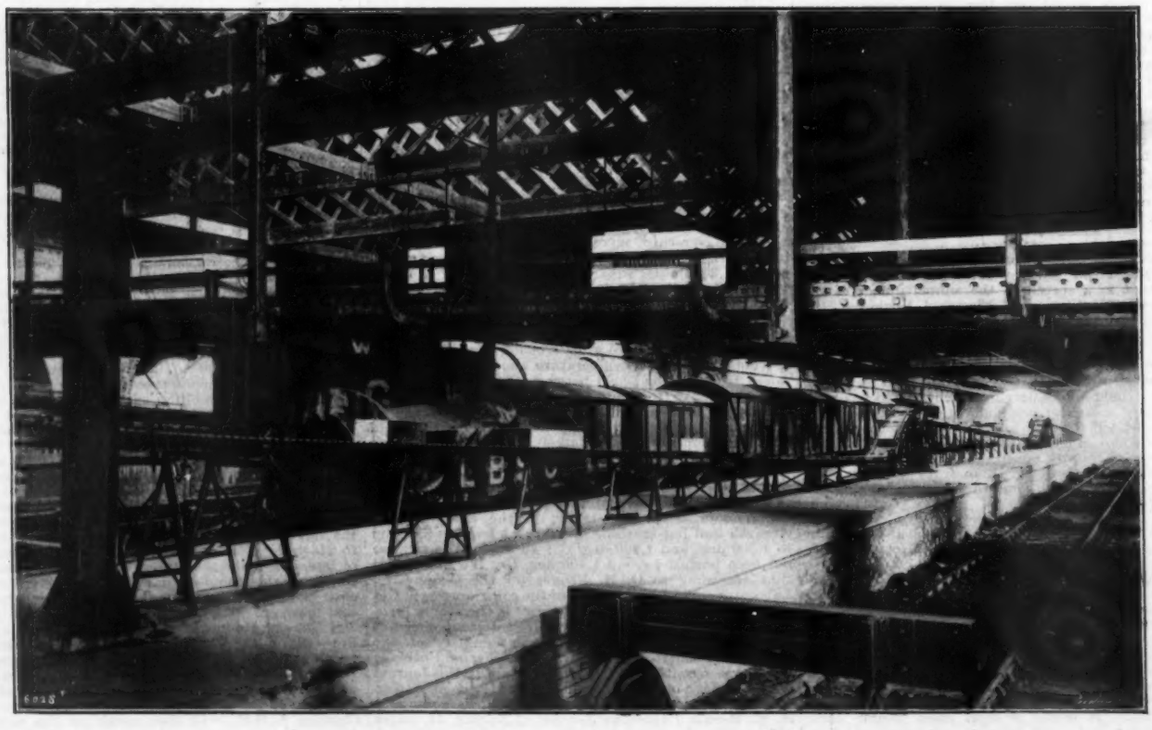


Fig. 39. Loading Platform Conveyors and Humpers.

CONVEYOR INSTALLATION AT THE MAYF

CONSTRUCTED BY MESSRS. W. AND

(For Description,

Fig. 26.

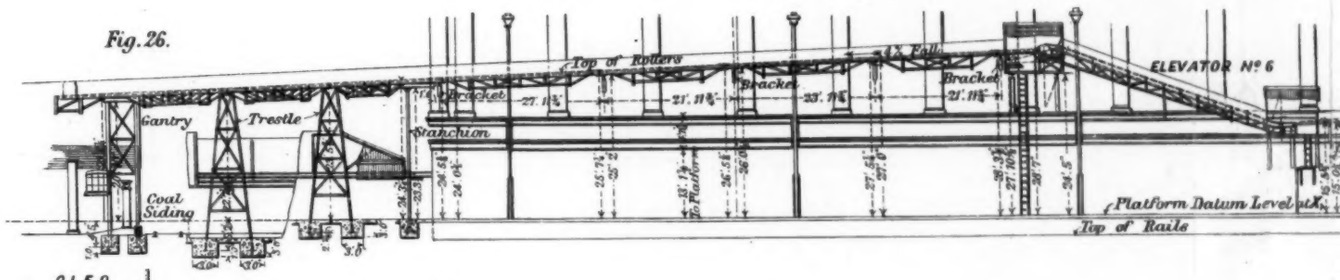


Fig. 27.

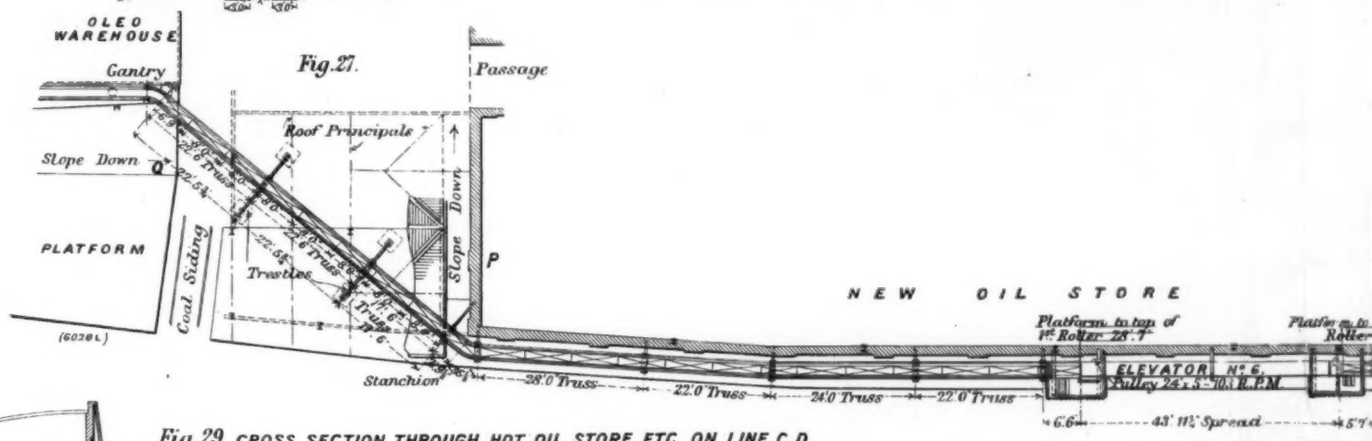


Fig. 29. CROSS SECTION THROUGH HOT OIL STORE ETC ON LINE C.D.

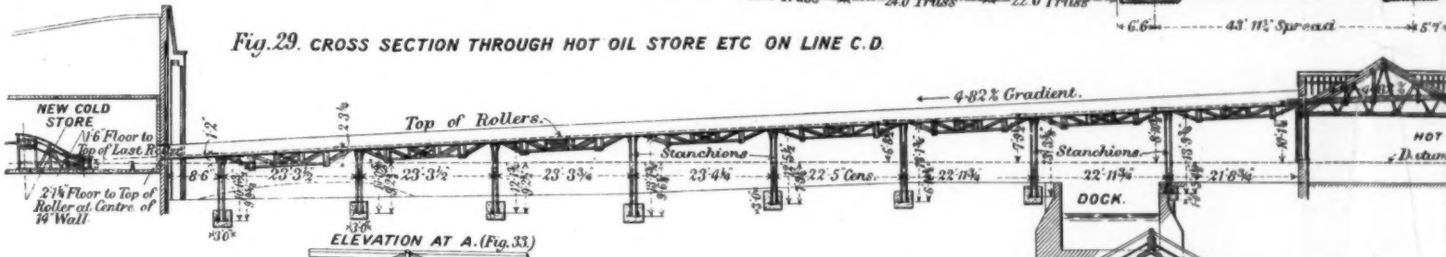


Fig. 31.

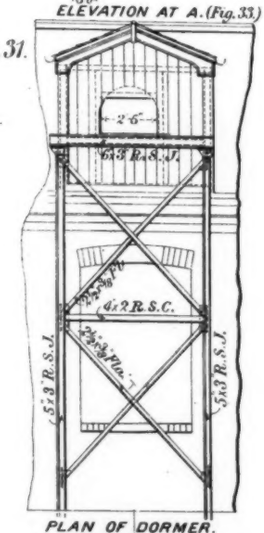


Fig. 32.

DETAILS OF DORMERS ETC., HOT OIL STORE.

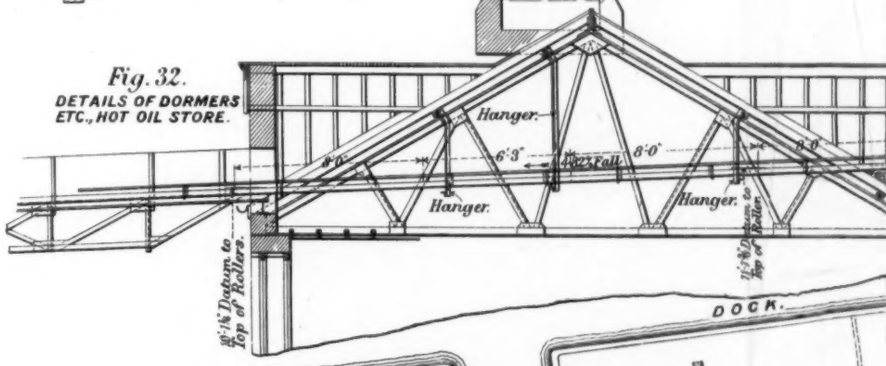
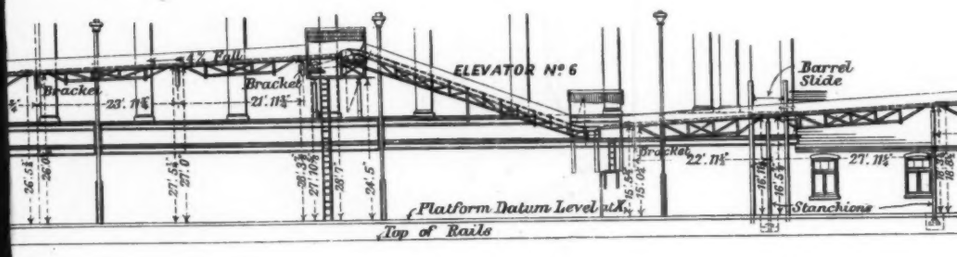


Fig. 30.

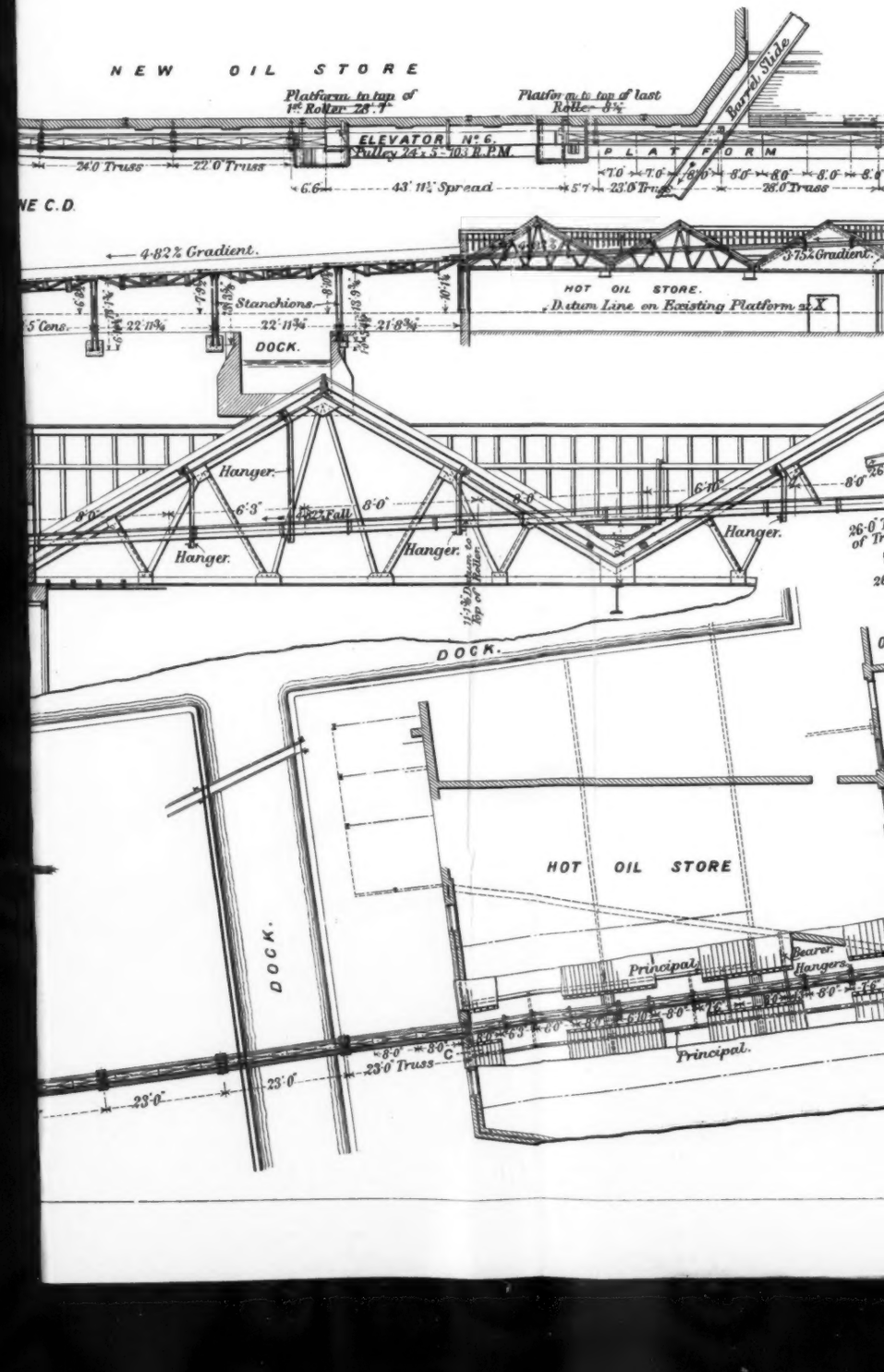
R INSTALLATION AT THE MAYPOLE MARGARIN

CONSTRUCTED BY MESSRS. W. AND C. PANTIN, ENGINEERS, LONDON

(*For Description, see Page 855.*)

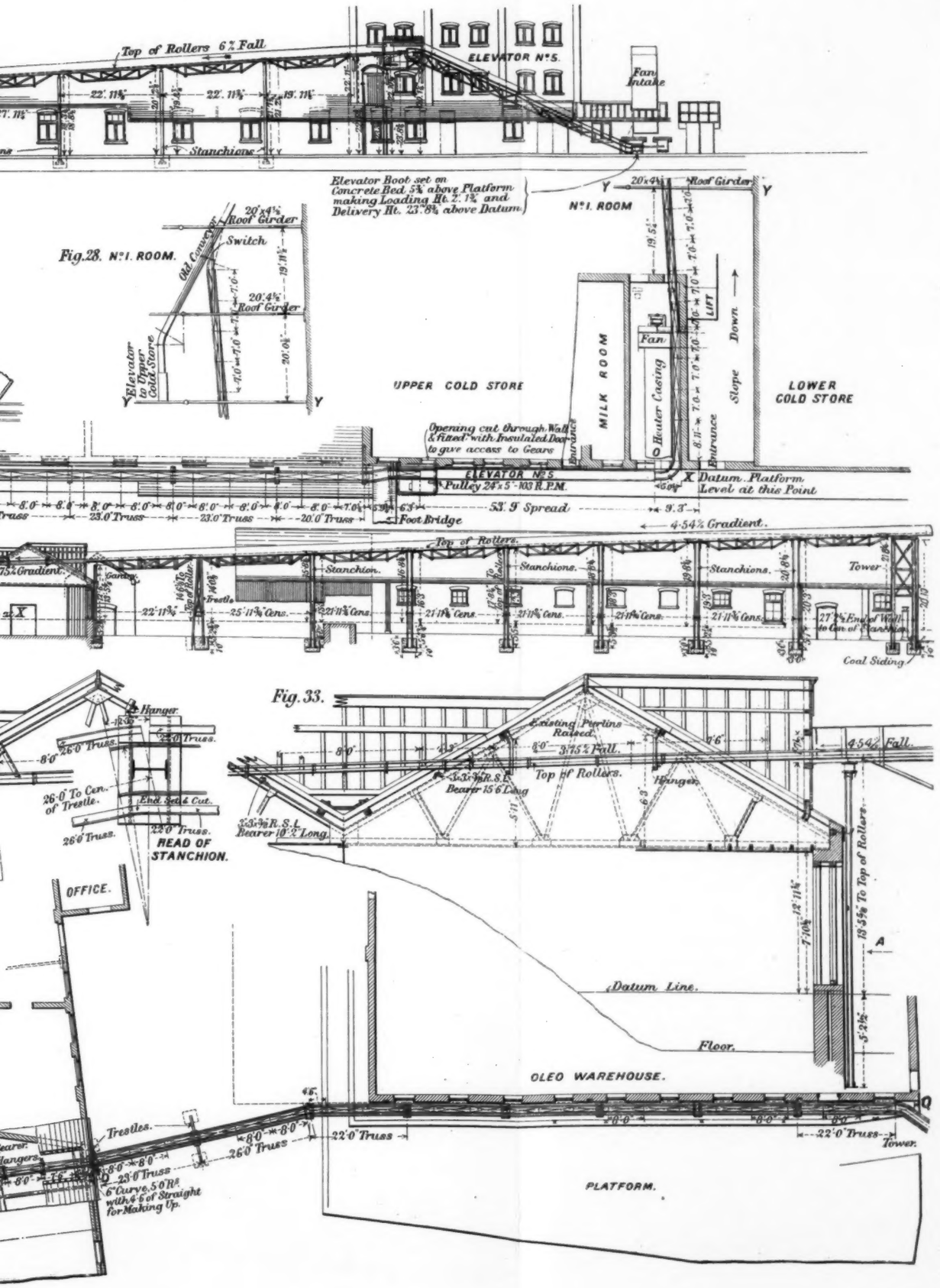


Fig



GARINE FACTORY, SOUTHALL.

RS, LONDON.



AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: S. F. Satchell, 86, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue.
For Advertisements, J. S. Allan, 18, Broadway, New York.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 3 0
For Canada—	
Thin paper copies	£2 18 6
Thick ,, ,,	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick ,, ,,	£3 7 6

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON,

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

CONTENTS.

	PAGE
Influence Lines Applied to Arch Design (*Illus.*)	843
Literature	846
The Works and Products of Messrs. Barr and Stroud, Limited (*Illus.*)	846
25-H.P. Vauxhall Motor Car (*Illus.*)	851
Industrial Notes	853
Royal Meteorological Society	855
Conveyor Installation at the Maypole Margarine Factory (*Illus.*)	855
Precise Levelling	856
Notes from South Yorkshire	856
Notes from Cleveland and the Northern Counties	856
Notes from the North	857
Notes from the South-West	857
Notices of Meetings	857
Engineering Developments during the War	859
The Study of Flotation	860
Economy	860
Frictional Resistance with Michell Thrust Bearings (*Illus.*)	861
The Use of Ferro-Concrete in Mines	861
Notes	862
The Institution of Mechanical Engineers	863
The "Restucci" Tube Scraper (*Illus.*)	866
Gas Engines	866
Disc Wheels for Motor Cars	866
Cutting Power of Lathe Turning Tools (*Illus.*)	867
Some High Temperature Tests of Refractories (*Illus.*)	875
ENGINEERING Patent Record (*Illus.*)	876

With a Two-Page Plate of the CONVEYOR INSTALLATION AT THE MAYPOLE FACTORY, SOUTHALL.

NOTICE.

Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase will date from and include the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 857.

ENGINEERING.

FRIDAY, DECEMBER 26, 1919.

ENGINEERING DEVELOPMENTS DURING THE WAR.

WHATEVER opinion may be held as to Mr. Wells's competence as a philosopher, there can be no dispute as to the extraordinary range and accuracy of his powers as an observer of human life and character. In the concluding paragraphs of his famous story about the first landships the defeated general is represented as protesting against "more ironmongery," and the record of the war and the effusions of certain old-school admirals since the conclusion of the Armistice has shown very clearly that this feeling of resentment to the disturbing creations of the engineer was very prevalent amongst officers of the army and navy. Under the stress of war, however, the contemners of "ironmongery," who, in the case of the navy, robbed us of the advantage of director firing, and in that of the army of an adequate supply of artillery and machine guns, had, perforce, to yield, since it was soon evident that it was hopeless to expect, following traditional lines, to overtake the start the enemy had gained by their many years of study and industry devoted to the production of the best equipped army in the world commanded by the best instructed officers. The beaten track was, perforce, forsaken, and for the first time in the history of our nation the engineer was given a relatively free hand. The traditional and seemingly inherent opposition of the lawyer and official to the creative mind was, for the time being, relaxed, and the work of repelling the menace of the Germans transferred largely from the official and the department to the engineer and the factory. Shells were demanded in quantities formerly undreamt of. The engineer provided them. With characteristic foresight the German had provided for the possibility that open warfare might prove impracticable and had ready effective trench mortars, the result of years of experiment and study. Within a few months we had improvised a better weapon in the Stokes gun, and when an effective reply was necessary to the extraordinary trench system on which the Germans had lavished all their wealth of erudition and such extraordinary industry, the engineer provided it in the tank.

Whilst thus improvising new weapons of every kind we had, at the same time, to make enormous additions to the Navy, and to the work done in this connection Sir Eustace D'Eyncourt devoted a large proportion of his highly interesting and instructive presidential address to the Junior Institution of Engineers on Friday last. He observed that in view of the fact that so much work of an entirely novel character was required in developing aircraft, smoke screens, blisters, and the like, it would not have been surprising had there been some slackening in the normal output of improvements in propelling machinery. Here the standard was already high at the outbreak of the war, and in view of the stress in other directions a policy of letting well enough alone would have had much justification. To some extent this was what happened, and Sir Eustace D'Eyncourt instanced the case of the heavy oil engines used on submarines where, he states, the Germans got considerably ahead of us during the war. On the other hand their aeroplane engines were far inferior to ours, and he makes the interesting statement that, so far as known, no German warship was fitted with geared turbines. It is in this connection that naval marine engineering has made the greatest progress during the war. By the adoption of the geared drive the propulsion-efficiency of turbine-driven destroyers was, he states, raised from 40 per cent. to 60 per cent. The result has been that higher speeds are obtained at full power, and there is a great saving of fuel at cruising speeds. In the case of larger war vessels the saving is not so great but remains, nevertheless, very substantial.

Some further data as to gears fitted on board ship are given in a valuable paper read last Friday before the North-East Coast Institution of Engineers and Shipbuilders by Mr. R. J. Walker. In this paper Mr. Walker states that Great Britain has constructed or has on order geared turbine machinery to an aggregate of 16,000,000 h.p. Single installations of over 100,000 h.p. have been fitted on certain ships, as much as 25,000 h.p. being transmitted through a single wheel, and as much as 15,000 through a single pinion. The efficiency of single reduction gear is, Mr. Walker states, fully 98½ per cent., that of double reduction gearing being over 97 per cent. The earlier installations had gears in which the angle of the helix was 45 deg., but Mr. Walker states that this is now being reduced to 30 deg. He is able to give most satisfactory statements as to the behaviour of the gears in service. With possibly one exception every case of trouble (and these have not amounted to 1 per cent.) has been traced to defective material, bad workmanship or faulty lubrication. In this connection he notes that in certain cases the teeth have shown signs of pitting, but this appears to be due to the metal having flaked off at spots of excessive pressure. This, however, does not seem to affect the working of the gears, and he states that the ss. Mahanada, of 12,300 tons, fitted with geared turbines, developing over 3,000 s.h.p., has run over 230,000 miles since pitting of the gear teeth was first observed. This experience confirms the dictum of the late Professor Sweet, who maintained that a mechanism which cannot wear out of shape will not wear much. It may be of interest to add that the theory of lubrication (as pointed out in our issue of August 11, 1916, page 121) gives reason for believing that it would be advantageous to ease off the points of the teeth for say $\frac{1}{32}$ in. or so. It would be interesting if this conclusion were tested in practice.

Other forms of gearing have also, Sir Eustace D'Eyncourt states, been tried in the Navy, but are all less efficient than spur reduction gear. The electrical system, has, however, some advantages at cruising speeds, and this is an important matter, since 80 per cent. of the steaming of war ships at sea is done under about one-tenth of full power. Electrical reduction gear was, he states, fitted on the K Class of submarine. These had a surface speed of 24 knots, which is from 6 to 8 sea miles in excess of the fastest German submarine constructed. To attain this speed it was necessary to develop 10,000 h.p. and this was impossible with Diesel engines owing to their weight. Steam turbines, with mechanical gearing, were accordingly fitted, but small Diesel engines were also provided, which were used just before, during or after coming to the surface. These were coupled to the propeller shaft by an electric gear. The boats were, he states, a great success. The Föttinger hydraulic device has, it appears, not been tried in our Navy, but was used on some of the German ships. Other forms of hydraulic gear of British origin and higher efficiency have, however, been tried experimentally.

The success of the geared turbine drive was, Sir Eustace D'Eyncourt notes, largely due to the adoption of the Michell thrust block. In the patent extension trial held before Mr. Justice Sargant last March the Admiralty representative admitted that 600,000*l.* was a not unreasonable estimate of the savings effected in the Navy by the adoption of this device in the war, and accord-

ing to further evidence its adoption in a ship of 11,000 h.p. reduced the machinery costs by 740*l*. No similar specific estimates as to the value of the device are given in the address under review, but Sir Eustace states generally that there is an improvement in efficiency of the machinery, an economy of lubricating oil and a very acceptable saving in the space occupied.

During the war oil fuel has become standard throughout the Navy. Sir Eustace D'Eyncourt says that during the war no less than 400 vessels aggregating 12,000,000 h.p., and burning oil fuel only, were added to our fleet. The advantages claimed for it are, in the first place, a great saving of labour which, during the war, left 150,000 men free for other occupations than the handling of fuel. Moreover, with oil fuel steam can be raised with extraordinary rapidity, and maintained over long periods of time without fires having to be cleaned. Again, the weight of the fuel carried is reduced 50 per cent., storage is simplified, and refuelling can be effected with great rapidity and in any sheltered spot. The great reduction in the amount of labour required to handle this type of fuel is, the speaker noted, leading some of our principal steamship lines to substitute it for coal, which has now risen to such a price that this policy is commercially sound. The danger, of course, lies in the circumstance that the supply of oil is scanty. In America, according to some authorities, an oil famine may be anticipated before the end of the next quarter of a century, and Sir Eustace D'Eyncourt notes that the present output of the whole world is not equivalent to more than one-twelfth the output of coal.

Of course, from some points of view the use of oil for steam raising is an abuse of a valuable and relatively scarce fuel, since if used in an internal combustion engine far more power would be developed per ton consumed than is yet possible with steam machinery. Unfortunately, however, the reciprocating engine is essentially a small power unit. Existing low-speed Diesel engines installed on merchant vessels develop only some 400 to 700 h.p. per cylinder, and weigh 250 lb. or more per horse-power. This figure is, as Sir Eustace states, prohibitive for any type of warship. Lighter fast running Diesel engines are, he says, available giving 1 h.p. per 70 lb. of total weights; but the power per cylinder is much less than with the slower running types, and this increases the difficulty of finding space for them. With steam the total weights on destroyers is only 30 to 35 lb. per h.p., and in battle-cruisers it is as low as 70 lb.

Some of the credit for these low weights must be attributed to the water tube boiler. These have not yet been much used in the merchant marine, as they are thought to be more expensive both to instal and maintain, but in the Navy their extraordinary steam-raising powers have made their adoption imperative. On war-ships, Sir Eustace stated, as much as 9000 h.p. is obtained from a single boiler.

THE STUDY OF FLOTATION.

In our issue of November 28 we commented upon the paper on the Study of Flotation which Mr. H. L. Sulman brought before the Institution of Mining and Metallurgy, on November 20, and we stated then that we should revert to the subject, the discussion of which was adjourned. The resumed discussion by the meeting of December 18 can hardly be said to have advanced matters much. The phenomena are very complex. Mr. Sulman has been anxious to consider all the possible factors, from the whole range of molecular physics, and by interpreting accepted facts and novel observations in his own way he has arrived—to use his own words—at a skeleton theory of flotation. In opening the discussion, Professor S. J. Truscott had remarked that it was impossible adequately to discuss such a *magnum opus*. Other speakers felt the same difficulty. Hence they confined themselves, if not entirely to congratulations, to comments on a few points.*

Professor Truscott differed from Mr. Sulman as to several points. Mr. Sulman had made his floating effect dependent upon σ_1, sin θ where σ_1 was the surface tension of the liquid and θ the angle of contact of the mineral. Since the sine of an angle had the values 0, 1, 0 respectively for angles of 0 deg., 90 deg., 180 deg., contact angles of 90 deg. should favour flotation, and smaller and larger angles should diminish it, whilst Mr. Sulman himself suggested that the tendency to float increased all the way as the contact angles increased. Professor Truscott would substitute the expression σ_1, cos θ for the sinking (not the flotating) effect; the cosines of 0 deg., 90 deg., 180 deg. being respectively + 1, 0, − 1, a particle should sink, float, or do neither according as θ was 0 deg., 180 deg. or 90 deg. This does not appear to agree with observations, however, and Mr. Truscott discussed the various cases by considering the action of a liquid on a plate standing vertically in it. Professor Truscott further doubted whether particles such as were dealt with in flotation, crushed through a 60-mesh screen, could be adsorbed and flocculated in the manner of the minute particles of 200 $\mu\mu$ maximum of which Mr. Sulman had spoken, and he suggested that it was essentially the violent agitation of the watery pulp which brought the particles into contact with myriads of air bubbles and made flotation possible.

In this latter respect he probably did not differ much from Mr. Sulman, who emphasised the kinetic character of the phenomena. But in his references to electric influences Mr. Sulman seemed to overlook that the electric forces of repulsion and attraction will chiefly come into play when the mass has quieted down to a froth, and he did not appear clearly to distinguish between the phenomena of electric currents and of electric fields. Mr. Sulman further explained this part of his views in the second meeting, especially referring to the researches of Mr. E. Hatschek—who was not present—on colloids and flotation, and we are not sure as to what he presented as his own views and what he attributed to colloidal chemists. He stated, we think, that in oily water the air bubbles, gangue and sulphide particles would all take negative charges. The addition of a little sulphuric acid (2 per cent.) would make the charge on the sulphide either neutral or positive; more acid would also change the sign of the charges on the gangue and air bubbles and would prevent electric separation, while the addition of alkali would make all the charges negative and not favour separation either. Bivalent and trivalent ions,—which have stronger effects in the coagulation of colloids than monovalent ions,—had, he found, no particular efficiency, and he considered in general that electric effects were not of great importance in flotation though he would not disregard them.

More regarding the electric aspect of the problems was subsequently put forward by Mr. F. J. Harlow and by Mr. Edwin Edser; the latter dealt at length with some common misunderstandings concerning the mutual repulsion (or attraction) between electrified particles in water, which would there be separated by millions of ions, and with electric osmosis and similar phenomena. But these considerations cannot profitably be reviewed in an article like the present.

Professor A. W. Porter pointed out that Mr. Sulman differed from most physicists as to complete wetting. A liquid would creep indefinitely over a solid, and complete wetting would take place when the contact angle θ was zero. Mr. Sulman made the further condition that the surface energy should be reduced to zero; if that were to be maintained a new term should be used. Water did not wet glass completely; the θ was 8 or 9 degs. according to Quincke, though 0 deg. according to Wilberforce; but Mr. Sulman gave a maximum value of 39·5 deg.,; was that glass, he asked, especially clean or especially dirty? Mr. Sulman had also questioned the high value of 4,000 dynes which Hulett had found (in 1900) for the surface tension of water against barium sulphate. A solution of 0·02 per cent. of sodium silicate, Hulett observed, changed in that case the θ to 90 deg.; when the solution was made several times stronger, the sulphate passed into a state of true suspension. Mr. Sulman would not accept the high value, because he assumed that a true suspension required the reduction of the interfacial tension to zero, and it was that assumption which was at fault, not Hulett's determination. As regards positive and negative adsorption, Professor Porter was in accord with Mr. Sulman, but he would go further. The pull on a foreign body in a liquid would either be inward, when the particles would concentrate in the interior, or outward, when the particles would concentrate in the surface layer. But, Professor Porter asked, why should not all the particles take part in this movement? It was a question of equilibrium between molecular and osmotic forces. Professor Bragg, who also took part in the discussion, contented himself with pointing out that the study of crystal structure by X-rays showed that the molecule was lost in the solid. In solids we had to deal with the atoms; Mr. Sulman had observed that on fresh cleavages water spread more readily than on old surfaces, and the reflection of X-rays by quartz, for example, was improved by rubbing off the old surface in which the atoms had had time to link themselves up.

We have not mentioned all the speakers, and we are aware that our brief summary cannot do justice to the author of the paper or the speakers. But the discussion from a general broad standpoint is still to come, and the phenomena remain obscure. Mr. Sulman acknowledged that his equation, $\cos\theta = \frac{\sigma_2 - \sigma_{12}}{\sigma_1}$, by means of which he reduces the questions to problems of interfacial tensions, involves two unknown quantities, σ_2 and σ_{12}. We know next to nothing about the surface tension of solids, and colloidal chemists will scarcely admit that it is possible to reduce an interfacial tension by the addition of acid really down to zero. Mr. Sulman certainly deserves great credit for correlating flotation facts and hypotheses, though one would like to have had references in his paper to literature on the subject, and we trust that further discussion will follow. In closing the meeting Mr. Hugh K. Picard, the president of the Institution, announced that the columns of their Bulletin remained open for further contributions on these important problems.

ECONOMY.

Probably the topic uppermost in the minds of everyone at the moment is economy, and with the present flood of spendthrift extravagance evident everywhere, the need for economy is apparent. We all desire to economise, usually at the expense of someone else, and indeed it is difficult to know where the cessation of expenditure is to begin. The current newspapers are full of warning and reproach, prominent statesmen and lesser dignitaries all devote floods of platitude in praise of thrift, or let loose words without end upon the subject. Talk will not end matters—it never did, what is required are the actions which speak louder than words, these alone have any real value. The thrifty who debarred themselves indulgence to save, find that the interest accruing to date, does not balance the depreciation of cash invested when its real value was greater in terms of commodities. Wages have risen, but purchase less rather than more, those who find any surplus are engaged in spending while there is yet time. The whole community is enmeshed in a vicious circle to which there seems no outlet. Regarding the practice of thrift, the best way to begin is—to begin, and until the need is driven home by sheer necessity helped by force of example, nothing will be done. Irrespective of individual hardship, it is better to begin pinching as an exercise for the pinch to come. Every single person who can at the moment limit desire and find satisfaction in lessening their needs, helps the circumstances of the hour.

We are faced with ruin and decay, unless a halt can be called to this rake's progress which is resulting in soaring prices and eventual want. We should all be working harder, double tides if necessary, cutting out circumlocution and waste, living more meanly, husbanding resources and trying to make ends meet. The whole question is complex, there is the issue of unemployment by shortening down, or improving means of production; but there is also the certainty of more widespread distress if from perverted philanthropy we retain obsolete methods or obsolescent processes. Coming to hard facts—industrial facts—is it not questionable whether

* We should mention that Mr. Sulman kindly directed our attention to an error, due to a misprint in a statistical figure on page 723 *ante*. This was corrected on page 753 *ante*.

diminution of hours will not defeat its own end in the long run? A man unable to support himself rationally on a real wage rate due to a shortened week is going to work overtime to secure the means to live, thus balancing income and expenditure by working pre-war hours. The manufacturer faced with an adverse balance sheet, will make his customers pay more, or revise his organisation, cutting this to the bone in an attempt to retrieve losses before disaster supervenes. There is a sense in which money has lost caste, we no longer respect a sovereign which is under 10s. in value, and trifles whereby economy can be effected represent nothing whatever. In former theological phrase the road to perdition is smooth and pleasant, and the path to a certain place (no longer dreaded) was paved with good intentions. On the surface at the moment there seems little awry, but that the outlook is more than grave cannot be disputed. Are we each and all limiting our wants, trying our utmost industrially and individually to minimise waste and secure economy by personal effort? Is there no way in which relatively small savings can be secured by rational consideration? Is it impossible in this day of grace to make thrift a virtue and its own reward? These are anxious times fraught with peril, and a spirit of *laisser faire* seems predominant.

During the war it was a disgrace to be idle and luxury was made ashamed; if production is the need of the hour, then it is as patriotic to win Peace as War. It is only industrial profit which can liquidate commitment and provide stability; are we destitute of means to the end, or must we become destitute first? Unable to feed ourselves, exports have to pay for a full larder, and while domestic prices rule high it is to be feared export trade is going to default. If a new world is to be gained, it can only be at the price of personal effort, by real grit wedded to outstanding intelligence. While the social system is in process of evolution and alteration, it is folly to withhold the toil which alone will give the benefit sought, however ill-distributed the present surplus may be. This England of ours, bought at so great a price, has weathered many storms, survived many struggles, and can only be sacrificed by intention and deliberate decadence. The duty that lies nearest, is to put strength and capacity into the task in hand, to live within our income by choice or of necessity, until the future becomes prosperous with the plenty we all desire.

The first step to retrieve the immediate past is stringent economy—the next is also stringent economy—by this is not meant cheeseparing (valuable though every small saving can be in the aggregate) but more particularly, the economy of improved means of production. From this point of view the engineer has a unique opportunity, it is through him, by his substitution of machine for muscle, by his resource and power that industry can win the future. High wages are in themselves no barrier, hostility to improvement is blank negation, and impoverishes everyone in the community. Just as the war was won in the machine shop, so the freedom from impending disaster can be gained in the same way. The spur of necessity was never so patent, it is only beginning to hurt, but unless matters alter radically in the near future, it will mean casualty and disablement too extreme to contemplate with equanimity. Let us get busy and economise, spending wisely without waste, limiting our desires to bare necessities for a season; if all help, and are in like case, there will not be the comparison of difference which hurts, but the spirit of common endeavour which sustains. Economy alone can prevent the tragedy all thoughtful minds foresee if the present state of affairs remains unaltered; cannot we recapture some of the fine fervour of the period just closed, and devote an equal space to win security from that most appalling of all spectres—want?

FRICTIONAL RESISTANCES WITH MICHELL THRUST BEARINGS.

IN a paper recently read before the Liverpool Engineering Society, Mr. H. T. Newbigin gave the annexed diagram showing the actual frictional resistance of Michell blocks as found in the careful experiments made in the laboratory of Messrs. Brown, Boveri and Co., of Baden, Switzerland. These experiments were described in our issue of June 28, 1918. Mr. Newbigin has reduced the results of these experiments to shearing resistances of the oil film in pounds per square inch section sheared. The chain dotted curves are plotted from the equation $R = 0{\cdot}0332\sqrt{\lambda V P}$. Here R denotes the resistance to shear in pounds per square inch, P the load carried, also expressed in pounds per square inch, V the speed in feet per second, whilst λ denotes the viscosity of the oil in C.G.S. units. In plotting the curves it is assumed that λ does not vary as the load is increased. As such an increase of load implies a thinner film of oil and a consequently greater rate of shear, this condition is not satisfied in practice as the temperature rise due to the additional work done on the film diminishes the average viscosity of the oil. It may, moreover, be observed that the formula is perhaps not wholly satisfactory in form, since the coefficient 0·0332 is not independent of the dimensions of the block. The block used in the Brown, Boveri experiments measured 4½ cm. × 4½ cm., and for a larger block the oil resistance would be smaller per square inch under shear if the blocks carried the same load per unit of area. In fact, by theory of units, if L, M and T denote length, mass and time respectively, R and P, being forces divided by areas, are both of the form

$$\frac{M\,L}{T^2\,L^2} = \frac{M}{T^2\,L}$$

whilst λ has the dimensions—

$$\frac{\text{force}}{\text{area}} \times \frac{\text{velocity}}{\text{length}} = \frac{M}{L\,T}$$

whilst V has the dimensions $\frac{L}{T}$. Hence if the coefficient in the above formula is to be independent of the dimensions of the block, the two sides of the equation should have the same dimensions. Substituting in the formula for R the dimensional values of R, P, λ, and V, we get

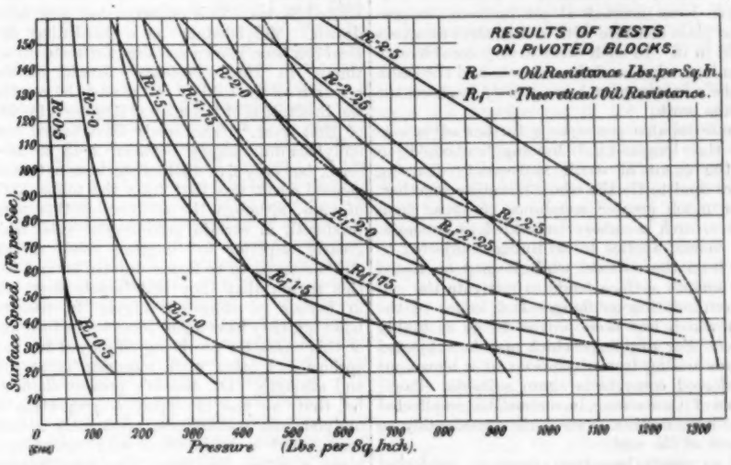
$$\frac{M}{T^2\,L} = \frac{M^{\frac{1}{2}}}{L^{\frac{1}{2}}\,T^{\frac{1}{2}}} \cdot \frac{L^{\frac{1}{2}}}{T^{\frac{1}{2}}} \cdot \frac{M^{\frac{1}{2}}}{T\,L^{\frac{1}{2}}} = \frac{M}{T^2\,L^{\frac{1}{2}}}$$

Hence the dimensional equation is not satisfied and the constant is accordingly not independent of the dimensions of the block. A similar consideration shows that the load carried per square centimetre of a block is also not independent of the size of the block and that the true law of comparison of similar blocks is that under similar geometrical conditions the load carried per centimetre run (measured transverse to the line of motion) is constant. There appears to be a misprint in Osborne Reynolds' paper ("Scientific Papers," vol. ii, page 264), where the equation

$$\frac{W}{a} = \frac{\cdot 16\,U\,a^2}{h_0^2}$$

should read:

$$\frac{W}{a} = \frac{\cdot 16\,U\,a}{h_0^2}$$



In the latter part of his paper, Mr. Newbigin gives the following formula for the load which may be imposed on a Michell block, viz., $P = K\lambda V$, where P is the pressure in pounds per square inch, λ the viscosity in C.G.S. units, and V the rubbing speed in feet per second, whilst K is a coefficient varying as the square root of the length. For a block 3 in. long, its value is 200, and this coefficient he states permits of irregularities in the surface of $\frac{1}{10,000}$ in. With specially good work the coefficient may, he states, be as high as 2,500, but the accuracy required to permit of this is greater than is obtainable in ordinary workshop practice. The Michell system has, Mr. Newbigin states, also been applied to journal bearings. With such journal bearings oil pressures of over 5,000 lb. per square inch have been recorded, as against the 600 lb. noted in Towers' experiments with a brass of the ordinary type.

THE USE OF FERRO-CONCRETE IN MINES.

FERRO-CONCRETE is one of the most ubiquitous of materials. Its advocates have brought it forward in connection with nearly every form of permanent immobile structure, and it is no longer necessary to elaborate any argument in favour of its use for bridges, floors, culverts, and so on. Reference to these points might, therefore, in our opinion, very well have been left, at this late day, out of the paper read on the 18th inst. before the Midland Institute of Mining Engineers by Monsieur T. J. Guéritte, president of the British Section of the Société des Ingénieurs Civils de France. The paper was entitled the "Applications of Ferro-Concrete in Coal Mines," and had the author contented himself with a fuller treatment of applications more or less special to coal mines he would, we think, have served his branch of the profession rather better. M. Guéritte certainly had, however, some very interesting types of structure to refer to in addition to subterranean work, as for instance the pit-head installations at the Bentley Colliery, near Doncaster, which are good examples of modern progress in this direction. The headstead for the second pit of this colliery consists of a reinforced concrete structure, 183 ft. long, 32 ft. wide, and 64 ft. high from foundation level to roof, the height to the headgear sheave centres being 109 ft. from the foundations.

The central feature of this structure is a block of concrete 50 ft. square and 6 ft. thick enclosing the pit mouth. This forms the foundation for the main frame, the columns of which are 36 in. square. The diagonal struts of the head frame are also of reinforced concrete. The concrete block above-mentioned supports 16 columns of the main building. The remainder of the building is carried by a concrete raft. In sites, as in colliery workings, where trouble may arise from subsidence the reinforced concrete raft would seem particularly suitable for large structures, while the success at the Bentley Colliery installations seems to promise well also for the use of reinforced concrete as a

suitable material for pit frames. In these days of difficulty in securing steel structural work this is not a point to be overlooked.

The more interesting applications which the paper refers to, however, are probably those underground, where the confined working space and the impossibility of handling large members often gives reinforced concrete work a very material advantage over structural steel, while in many applications it provides strength to withstand the effects of explosions, a feature lacking in brickwork or plain concrete. Insets, for instance, of reinforced concrete have been inserted at pit bottoms, in preference to plain concrete with arched steel members embedded in it. In such cases a very considerable reduction in thickness of the concrete and the small size of the reinforcement have greatly lessened the cost of the work.

The material also possesses a further advantage due to the longitudinal bracing embodied in it. In the event of earth movement occurring these bars tend to tie the whole structure together, and offer much greater resistance to shear than would steel arch members embedded in concrete. This, of course, applies to all linings subjected to pressure from the outside, while it may be stated that the smooth surface tends to mitigate the evil of the accumulation on flanges and ledges of the fine dust which has been proved to be so highly dangerous. For stoppings which may be subjected to pressure arising from explosions or a blown-out shot reinforced concrete is again suitable. Partitions made of it are strong, incombustible, unaffected by water and, further, contribute considerably to the support of the roof.

When so much has been done in reinforced concrete above ground to replace by permanent material such perishable articles as wooden fence posts, poles, &c., it is not surprising that the attempt should have been made to find in it a substitute for pit props, especially during the last few years when props were difficult to get. For many reasons reinforced concrete would seem to be an ideal substitute, especially by reason of its high resistance to crushing, but there are difficulties presented by it which have not yet been satisfactorily overcome. On the one hand, the reinforced concrete prop will carry large loads and is practically indestructable by age or fire. If failure occurs under loading, the end and not the middle of the strut gives way, and a damaged end can be dressed and the prop re-used. However, on the other hand, such props are much heavier than timber, are difficult to cut, and are liable to damage by hammering or wedging. There is therefore a field open for investigation in this direction and M. Guéritte states in his paper that experiments are being carried out with a view to lightening props of this type and also to making it more easy to cut off, if necessary, a few inches at either end.

NOTES.

The Government's Coal Proposals.

The proposals of the Government regarding the coal industry formed the subject of a statement by Sir A. Geddes in the House of Commons on Monday, the 22nd inst. Sir A. Geddes summarised the situation by stating that increased capital employed in the development of the industry must be remunerative; that the Sankey wage must be regarded as part of the working expenses; and that as the coal of some collieries is retained in the country for sale at a low and unremunerative rate, those collieries which are benefitting by a large export trade at the present high rates, should be made to contribute to the relief of the firms supplying coal for use in this country. The coal industry remained controlled and will so remain till August next. The Government, it is said, is endeavouring to arrive at an agreement with coalowners on the lines suggested above, in order to make the inland collieries self-supporting. It is intended that the special contribution to be exacted from the exporting collieries, and the compensation granted to the inland collieries should as nearly balance as possible, and a fair and equitable distribution of the total profits of the industry be arrived at. In the event of an agreement not being found possible, the Government will formulate its own proposals. In either event the scheme will be embodied in a Bill and laid before the House after it reassembles. The difference between home and export prices for coal is about 30s. at the present time.

Molybdenum Steels.

A good deal of notice has been given in the past few days to the announcement that Dr. J. O. Arnold of Sheffield had discovered a new molybdenum tool steel, but had been prevented by the Government from pushing on with its commercial application, though free to take such action in the United States. This embargo has now been withdrawn. Molybdenum as a hardening agent for steel has been known and used for some considerable time. In 1915, Professor Arnold concluded a research on the subject and placed the results before the Institution of Mechanical Engineers in November of that year.* The steels then tested contained molybdenum ranging between 2·43 to 20·70 per cent., but only five distinct steels were tested. The general result was that from the toolmaker's point of view, although the addition of this constituent produced, in certain percentages, steel which was greatly superior to tungsten steel, molybdenum steels seemed to be rather unreliable, and it was for this reason that they had largely been discarded in favour of tungsten alloys. In recent years, however, they have again come to the fore, and steels of this character are being employed for motor car springs and other work requiring great toughness and strength. Dr. Arnold's present claim seems to be that he has hit upon a proportion for the molybdenum constituent, apparently about 6 per cent., used in conjunction with vanadium, which gives a better tool-steel than any hitherto produced. The question will turn ultimately upon the supply of molybdenum, which is not produced in very large quantities at present, and is about four times as expensive as tungsten. The production of the United States runs to rather more than 100 tons per annum and a certain amount comes from Canada. For use in anything like large percentages the supplies will have to be very greatly increased to bring the steel within the range of commercial usefulness. In the United States the chief sources of supply are Arizona, Colorado, Utah and New Mexico, while the Canadian deposits worked are in Quebec and in the Rocky Mountains.

The Acid Test of Manufactures.

In all mechanical matters a long sequence of complex activity—part mental, part manual—results in the production of a machine, plant or device. Behind all the immediate activity which results in the product of to-day is the shadowy past which has contributed to its evolution. Thought, skill, labour and pains are all employed to a given end meeting and overcoming obstacle, failure and disappointment. The resultant is the completed job. It is then very often placed under test conditions which verify and endorse its precedent phases; and it is often assumed that because it fills expectations in this particular it is successful. Thence it passes to the customer for whose order the commercial side have cultivated the diplomatic art. The goods are sold, the transaction ended, yet one thing remains. In operation the product of toil and skill may fall into ignorant hands, may be misused, abused or maltreated, yet the plant or machine under such adverse circumstances is expected to function with efficiency or economy. To come to the point, the acid test is that of use. There are many things which by care under ideal conditions prove satisfactory; there are others which even by practical understanding and reasonable working fail; but complaint is certain, if, even when operated by a fool, there is trouble. Reputation hangs in the balance; ofttimes, owing to human delinquency and want of knowledge great harm is done. It must be remembered that only a portion of mechanical product gets into skilled hands. The ubiquity of the machine and its advantages lead to its abuse in hands alien to mechanical understanding, who pay scant respect to mechanism as such. It is against the worst conditions that provision has to be made. For these reasons, sterling commonsense in addition to expert mechanical ability is needed on the part of the designer. They also point to the need for simplicity and the much vaunted foolproof construction whereby inexpert intention is frustrated. Certainly some increase in mechanical understanding is becoming general, but what to the expert is simplicity, may resolve itself into perplexing problems when faced for the first time by an outsider. The acid test is use—not expert use, but general—and this points to the merit and value of reputation which has been built upon experience of market and requirement.

* See Engineering, vol. c, pages 550 and 555 *et seq.*

Electrochemical Developments.

The review of the development of the electrochemical industry which Dr. Hans Goldschmidt, of Essen, gave last September, in the *Zeitschrift des Vereines Deutscher Ingenieure* (on pages 877 to 883 and 918 to 923), refers to some features which have not been discussed in similar recent papers. Of the various aluminium processes supposed to be worked, he points out, only the original decomposition of alumina and cryolite in graphite-lined iron furnaces is really in use, and this process is mostly (except in America, where large units are the rule) worked on the old lines in small units of about 100 h.p. Large plants, therefore, require many furnaces, much current is wasted in the leads and connections, and the electromotive force actually used is higher (6 volts or 7 volts) than is believed; besides there is further waste in the preparation and drying of the aluminate. The establishment of new German aluminium works we have mentioned on other occasions; the attempted preparation of alumina from clay has not been successful so far. The much advertised Serpek process, which gains ammonia and sodium aluminate by treating the first-prepared aluminium nitride with caustic soda, had nowhere actually been adopted according to Dr. Goldschmidt, before the war at any rate. Magnesium is produced in large amounts by the electrolysis of fused carnallite, one of the Stassfurt salts. The alloy "elektron," consisting of magnesium and 5 per cent. of zinc, can be rolled and extruded, but only by experienced men; magnesium itself oxidises more than aluminium, and as it continues to burn if once ignited, it is not used on switchboards or on flying machines. The difficulties of the large calcium carbide furnaces are the dust and fumes and heat. The tap holes, one under each of the three electrodes (three-phase), are opened with the aid of auxiliary arcs; the whole neighbourhood suffers from the fumes, and electric precipitation of the fumes by the Cottrell process has not been very satisfactory so far. The calcium carbide industry has made great strides in Germany during the war, yet the preparation of acetic acid and alcohol from the carbide does not look promising. In the manufacture of nitrolim nitrogen has to be bound by the hot carbide; attempts to effect this combination with the hot carbide as it flows from the carbide have failed, and the cooled carbide has still to be heated up again. As regards ferro alloys, more ferro-tungsten is made in electric furnaces now than of tungsten reduced by carbon in crucibles; high-grade ferro-tungsten has, however, a high melting-point and the furnace walls have to be taken down to get each charge of about 1 ton out. The extraction of tungsten from the old slag dumps was, of course, only a German war industry. German ferro-chrome, Dr. Goldschmidt thinks, produced in electric furnaces in which, however, a uniform low carbon percentage is difficult to secure, will be able to survive, provided the chrome ore be obtainable; in that respect the general outlook, in this and other fields, is very gloomy. With regard to zinc, a very pure zinc is being distilled in Scandinavia and Germany from ordinary zinc in electric radiation furnaces. Electro-steel is made in furnaces of the three main types: Stassano, Héroult-Girod-Nathusius, induction. A saving in ferro-manganese can be effected by fusing the alloy before its addition to the steel, but the manipulation requires skill. The chief electrolytic alkali processes worked are the Griesheim, Aussig, Billiter and the new Gauss process of the Badische Anilin-und Sodafabrik. The bell cells of the Aussig Company (which also makes graphite) do not, according to Goldschmidt, require frequent repairs, as has been suggested,

but they only answer for the decomposition of KCl, not of NaCl; the latter would yield too much soluble sodium chlorate. The utilisation of the chlorine from the alkali cells is one of the German post-war difficulties, especially as the supply of scrap, to be detinned by dry chlorine (Goldschmidt process), may fail.

STREAMING METAL-VAPOUR ARCS.

About a dozen years ago Schönherr succeeded in producing steady arcs, several metres in length, in vertical tubes, and these arcs were utilised for the oxidation of atmospheric nitrogen. Mercury arcs have long been known, but had so far been limited to vacuum vessels. Two years ago, E. Podszus managed to obtain long steady arcs of mercury and amalgams in vessels charged with gases at atmospheric pressure. In his publication, in the *Zeitschrift für Elektrochemie*, of June 1, 1919, which has only recently become available over here, he mentions that he had to interrupt those researches, and he has apparently not been able to resume them since. His first apparatus was a bulb resembling an inverted U; both the limbs of the U were open below and closed by mercury seals; the anode, a piece of tungsten, was attached to a rod which was mounted in the top of the vessel and could be pushed down and up by hand. The cathode, the characteristic feature of the apparatus, was a quartz cup filled with mercury, open both at the top and bottom and communicating with the mercury in that limb. The upper part of the cup formed a nozzle. When the tungsten anode was pushed into the nozzle, to strike the arc, some mercury was evaporated; when the anode was pulled upward, the vapour pressure forced a steady stream of mercury vapour against the anode above the cup. An electromagnetic arc-striking device did not answer. The second form of apparatus resembles an inverted spherical glass bulb with a short neck, closed below by an iron cap which serves as mercury tray. Three tubular parts are mounted in this cap: a tube for filling the bulb with gas; the cathode, in this case an iron tube; the anode holder which is pushed up and down as before, so as to keep the anode vertically above the cathode. The cathode tube of iron is partly filled with mercury, and in the mercury stands a concentric tube of boron nitride a highly-refractory insulating material which Podszus prepared some years ago; the cathode proper is a tungsten nozzle mounted on the iron tube, but insulated from it by boron nitride. The thickness of the arc, it was found, depends upon the gas pressure and the current intensity; increasing pressure narrows the arc, and the arc is thinner in hydrogen than in nitrogen; increasing current makes the arc wider. The colour of the light changes with the nature of the gas. The mercury arc looks greenish-white in hydrogen and bluish-white in nitrogen; when the mercury is replaced by amalgams of the alkali metals, the colour of the metal vapour is seen, and the mercury colour vanishes. The presence of vapours (in the place of the indifferent gases hydrogen and nitrogen) influences the colour; there is generally a small anode flame of the colour of the element, and the compound is reduced. Thus boron chloride is reduced to boron; $TiCl_4$ is partly reduced to titanium metal, partly to $TiCl_2$, the other product being mercurous chloride; in air large masses of mercury oxide are produced; whether or not nitrogen is oxidised by this mercury arc is not certain. The potential gradient in the arc decreases when the gas pressure is diminished and when the current intensity is increased; it is much larger in hydrogen than in nitrogen. With a total gas pressure of 1 atmosphere, and with an excess of gas pressure in the cathode amounting to 3 cm. of mercury, the potential fall per millimetre was 8 volts at 10 amperes and 5 volts at 14 amperes in hydrogen; in nitrogen 2·5 volts at 7·5 amperes, on 220 volt circuits.

COAL REBATE.—A committee consisting of Mr. Roger T Smith, president of the Institution of Electrical Engineers (chairman) and representatives of electrical associations, has had several interviews with the Coal Controller and has drawn up a memorandum to show how the reduction to be made to electricity consumers to correspond with the 10*s.* reduction in the price of coal is to be carried out.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of this Institution was held on Friday last, the 19th inst., at the Institution House, Storey's Gate, Westminster, the chair being taken, in the absence, through continued illness, of the president, by Captain H. Riall Sankey, vice-president. The chairman opened by referring to the loss the Institution had sustained in the death of Mr. J. Hartley Wicksteed, whose career we dealt with last week. It was announced that the council had that afternoon drafted a letter of condolence to his widow.

The minutes of the previous meeting were then read and the chairman further announced that the council had made a grant of 2,000*l.* towards the James Watt memorial, the instructions being that the money was to be spent in the construction of a building at Birmingham. The situation was best explained by the letter which had been sent to Mr. Askwith Ellis, the secretary of the James Watt Centenary. The letter was as follows: "The centenary of the death of James Watt is an event of universal interest to engineers, but to none more so than to the members of the Institution of Mechanical Engineers. Many of the members were privileged to join in their individual capacity in the recent celebrations at Birmingham, at which the Institution was also officially represented. The proposals of the Birmingham Commemoration Committee to found a Watt International Permanent Memorial have been reported to the Council of the Institution, and have had their careful consideration. The council hope that the memorial hall which it is proposed to erect will be a worthy memorial of the genius of James Watt, and have pleasure in informing you that they resolved unanimously to offer a sum of 2,000*l.* towards the cost of the building."

CUTTING POWER OF LATHE TURNING TOOLS.

A paper on the above subject, bearing the title "Cutting Power of Lathe Turning Tools: Part II (being an Account of Further Experiments made in the Machine-Tool Laboratory of the University of Sheffield)," by Mr. George W. Burley, was then read in abstract by the author. We print this paper in full in another part of this issue, and may therefore at once proceed to the discussion. Part I of the paper, which was a joint contribution by Professor W. Ripper and Mr. Burley, was read in November, 1913. A reprint of the paper, together with a report of the discussion, will be found in our issue of November 28, 1913.

Professor W. Ripper was the first speaker. He referred to the death of Mr. Wicksteed, remarking that in this relation he spoke as one of the old brigade. He wished most sincerely to join in the expression of deep regret at the loss of so valuable a member. All who had known Mr. Wicksteed knew him as the sound and strong man that he was. Mr. Wicksteed was not only a great engineer, but a man of great quality, and one whose life was not easily spared.

Turning to the subject of the paper, Professor Ripper alluded to the able service of the author in the conjoint preparation of the first part of the paper, and observed that he (the speaker) had not taken any share in the preparation of the second part. The genesis of the first contribution was perhaps attributable to reflections then current upon well-established ideas as to the behaviour of cutting tools; and it was felt that something should be done to confirm the opinions. Every possible variable was cut out; the tool angles were standard, there was no lubrication, and standard angles of rake were used. Upon such conditions, they could have no claim to base general laws for the behaviour of cutting tools; all that could be done was to indicate the principles which should obtain. In the discussion which followed the reading of the first part of the paper, the aim of the authors was lost sight of, and the results of the experiments were not regarded as comparable to workshop practice. That circumstance was probably due to the fact that the laying down of general principles and the avoidance of a number of variables were inadequately dissociated in the first paper. The formula recorded in Part II showed great improvement upon the original formulæ, which, of course, did not represent, and were not intended to represent, practice under the best conditions.

The Professor stated that he had had the formulæ collected, and would suggest that the Institution might afford him an opportunity of reading a paper upon them which would show their evolution. These formulæ would allow of tables being got out for all ordinary practical work, account being taken of the work, the material, the tool, &c., and the addition of such tables would add to the value of the paper. The latter, of course, was not exhaustive, and merely dealt with the turning of steel. A multitude of other considerations required investigation in connection with lathe work, and there was much work to be done by those who had the patience and opportunity to carry it out in the future.

Mr. P. V. Vernon congratulated Mr. Burley upon his arrangement of the paper, which was useful for analysing purposes, and upon the patience which had characterised the work, as well as the method of carrying it out. The speaker did not, however, entirely agree with the results obtained, and he would put forward some arguments which might indicate the advantage of further investigation. The first question with relation to such papers was the extent of the help they would afford to the practical engineer. The speaker had not found much in the present paper that would assist in that direction; the main conclusions were within existing knowledge. He would cite the author's table of speeds at which finishing cuts could be taken, and would point out that it was nowadays uncommon, in the case of small work, to take finishing cuts on a lathe, the better practice being to finish by grinding. With larger work finishing cuts were perhaps necessary, but every endeavour should be made to do away with them. In the future it was probable that engineers would grind on the larger work also. In the case of small bar work, where grinding was not done it was usual to finish with a plane or, preferably, a roller steady. Speaking of the very large quantity of steelwork made from the bar on a turret lathe, it was not the tool that did the finishing, but the steady. The speed at which finishing could be done on mild steel was given, in the paper, by tables, he believed, up to 48 ft. On a bar lathe using a roller steady, that speed would be regarded as behind the times. In fact, in experiments made by his own firm, finishing cuts had been successfully taken at a cutting speed of 295 ft. per minute. Speaking of durability, Mr. Vernon considered that account should be taken of the fact that the durability of the tool was seldom a determining factor. In using a lathe, it was not the point to try to save tools, except in such a case as that of boring a marine engine cylinder, where the aim was to take a finishing cut without changing the tool. In ordinary work the object was output, and it frequently paid to use the tools up quickly, and rapidly replace them. Therefore, the question of durability of the edge of the cutting tool was seldom of importance. On a bar turret lathe for taking work up to 2¼ in. or 3 in. diameter it might be said that no single cut ever taken occupied 20 minutes, using modern tools, and, that being so, it was unimportant to aim at making a tool which would last that time.

With regard to angles, he noticed, from the paper, that the maximum rake tested by Mr. Burley was 35 deg., while the majority of good results were obtained with tools having a top rake much less than 35 deg. Apparently no tool of the kind now used for turning bars on turret lathes had been tested. A standard tool of that class had an ordinary working top rake of 35 deg. The rake was all side rake, no front rake being used. The clearance found advantageous was 7 deg., as against Mr. Burley's 5 deg. of clearance. The tool was that which took a heavy roughing cut at 295 ft. per minute. He would submit the following figures in relation to it. It was a high-speed tool, the section being 1 in. deep by ¾ in. wide, and it would reduce a bar from 2¼ in. to 1 in. with 500 turns per minute. This was equivalent to 295 ft. on the outside of the bar, and to 44 cuts per inch, removing 32·3 cub. in. of metal, or 9·04 lb., per minute, as actually measured. This figure might not agree

with calculations, because on a heavy cut the machine would be slowed down a little. Similarly a 2½-in. bar was reduced to ¾ in. at 34 cuts per inch, removing 36·11 cub. in., or 10·11 lb. Again, a 2-in. bar was reduced to 1 in. at 256 turns per minute, equal to 134 ft.; at 20 cuts per minute the metal removed amounted to 27·68 cub. in. per minute, or about 7·75 lb.

It appeared to Mr. Vernon that this tool was the right kind to use in experiments, on account of its higher output. Moreover, it used less power than any of the tools forming the subject of the author's paper.

With regard to the sixth point made by the author, the speaker felt that it was a mistake to talk about the height of the cutting edge as having anything to do with the efficiency of the cutting edge of the tool. Height in itself was nothing; what should be taken was the relation between the dimensions of the tool and the line joining those points to the centre of the work. Increase of height simply reduced top rate and increased clearance. It was therefore deceptive to talk about whether a tool should cut high or low; it should not cut either high or low, but the angle should be proportioned to the work. It was interesting to learn from the author's experiments that there was no advantage in forging tools, as the conclusion strongly supported the use of the modern tool-grinding machines, which produced tools from bar steel more quickly and cheaply and, generally, more accurately, than when the tools were forged.

Finally, Mr. Vernon referred to the author's conclusion as to the relation between cutting speed and horse-power used in cutting. Some years ago he had made an hydraulic indicator for measuring the torsion of a tool. This consisted of a spindle mounted on ball bearings, with a lever attached to an hydraulic cylinder and a gauge for measuring the torsional pressure; the end pressure was measured separately, by similar apparatus. It was found that in drilling, and tapping and turning, there was no appreciable difference in the torque required to turn the drill round or the tap round, or the work round against the turning tool, no matter at what speed these were being worked. He found the fact difficult to believe, because he could not see how the tool could work faster against the work unless it had a harder push, or how the work could work faster against the tool unless it had a harder push. The harder push would indicate more energy, but the measuring instrument described did not indicate any greater energy at all.

Mr. R. J. A. Pearson stated that he would regard with interest a similar investigation to that of the author for the case of the tools producing repetition work. He instanced the broach, which he believed would have a great future when the newer methods of production supplanted the old, and he considered that research in the direction named would be advantageous. Good broaching did away with the expensive hand operations required in putting the work together, and the acquisition of reliable data, such as that given by the author, in relation to the broach would be of great assistance. As tools cost a good deal of money, it was desirable that, once made, the results should reflect favourably on the cost of the finished article. Mr. Pearson then referred to certain experiments in reamering which he made, and the results of which he hoped he might, at a future time, place before the Institution. The ordinary adjustable reamer had a square edge, something like the tool used by the fitter for scraping, and was, in fact, in the nature of a scraper. In the experiments he had made he had found that by putting a lip on the reamer much better results were obtained in regard to finish. As yet, however, he could not submit data as to durability, the number of pieces that could be reamered, &c., but in his present remarks he desired to emphasise the value of experiment on tools used for the production of a large number of articles within certain fine limits.

Mr. T. F. Kayser, who spoke next, raised the question of the effect of temperature on the cutting efficiency of high-speed tool steel. The Brinell hardness was usually taken in the cold state of the metal, but when the tool was at work it, of course, became hot. He had invented a machine for determining the Brinell hardness at high temperatures. He employed an anvil in a heating tube. The specimen under test was hardened and then placed on the anvil and heated up. A weight was then allowed to fall, and behind the ball was a standard of known Brinell hardness. Whatever the energy of the blow, the same amount of energy was put on both the specimens, and, knowing the Brinell hardness of the specimen behind the ball, it was possible to calculate the Brinell hardness of the specimen under test, by measuring the two impressions.

Mr. Kayser stated that he had dealt largely with two steels, (1) containing 18 per cent. of tungsten, 1 per cent. vanadium, and 1 per cent. molybdenum, and (2) a cobalt-molybdenum-chrome high-speed steel, containing about 0·6 per cent. of carbon, 6 per cent. of molybdenum, 5 per cent. of cobalt and 4 per cent. of chromium. He had hardened the tungsten steel out in an electric salt bath at 1,300 deg. C., quenched it in oil, and then tempered it at 620 deg. C. The cobalt-molybdenum-chrome high-speed steel was more adaptable, because the hardening temperature was much lower. This steel was hardened from 1,120 deg. C.; quenched in oil, and then tempered at 550 deg. C. A large number of Brinell hardness tests were applied, showing that the cobalt-molybdenum steel was undoubtedly superior for a turning tool, having less falling-off in hardness with increase of temperature. This was confirmed in practice.

As to the forging of tools, it was considered, metallurgically, that the nose was forged in order to put more metal into it, thus enabling a section of ½ in. to be used as if it were ½ in. by ¾ in. There was, however, no gain in cutting efficiency; in fact, high-speed steels made quite efficient turning tools if used in the cast state. It was not necessary to forge them at all, but cast to shape, annealed and hardened they were quite efficient. He had found a further point of interest in connection with high temperatures of cutting tools. In hardening a high-speed steel in the usual way it was allowed to cool down to the room temperature then ground and put to work. The cutting edge temperature might be raised to 300 deg. C. or to 400 deg. C., and yet the tool would cut quite satisfactorily. If put to work after cooling down to 300 deg. C. the tool would instantly fail. The tool should be cooled down below, say, 100 deg. C., and then raised to 300 deg. C., when it would cut quite efficiently for practically the normal length of time.

Mr. Edward G. Herbert said that he had, perhaps unwittingly, given the inspiration for some of the researches which had been laid before the Institution by Dr. Ripper in his original paper and the author in the present paper. The statement was made that the research was undertaken in the first place to test the remarkable results produced on the Herbert testing machine which he (Mr. Herbert) originated, and, further, that some of the subjects dealt with in the present paper were inquired into in consequence of the discussion which took place on Dr. Ripper's paper. He believed that he himself suggested that Dr. Ripper should leave the slogging tools alone a little bit, as they had been investigated *ad nauseum*, and deal with the finishing tools on which no researches had been made. The present paper dealt with a very wide range of subjects, and he was rather at variance with the remarks which Mr. Vernon had made in regard to it. It struck him that the paper was of very practical interest and was one such as might be handed to a workman, who would understand the matters dealt with because they had a direct bearing on his work.

With regard to finishing cuts and the degree of finish produced at various speeds, he had no criticism to make on the test methods adopted. The visual method was perhaps unscientific, but finish had to be judged by visual methods, and on the whole it worked very well. The only suggestion he desired to make in case any further investigation was made on the subject was that enlarged photographs of the surface gave a very excellent idea of the kind of finish produced, and would enable ordinary people, as well as the trained observer, to judge the degree of finish. Turning to the durability tests, he thought every practical man must have been struck by the extremely low durability shown in them. A tool, which was set at ·004 in., was not only blunted after 20 minutes' running at a speed of 23 ft. a minute, but it was so blunt that it absolutely lost its cut. To a practical man the question naturally presented itself, if that happened at a speed of 23 ft. a minute, what would happen at a speed of 40 ft. or 80 ft. or 120 ft. a minute? If the curves in Fig. 74 of the paper were continued in the direction which they appeared to be taking, it seemed to him they would strike the zero line somewhere about perhaps 30 ft. or 40 ft. per minute, which would lead to the conclusion that neither with a high-speed tool steel nor with a carbon tool steel could they cut at all at the speeds which were being used in the workshops, because the tools would give out instantly. The high-speed tool apparently lasted 16 or 18 minutes at 30 ft. a minute. It must have struck those who were accustomed to use tools running with just as hard materials at speeds four or five times as high that that was something rather strange, and they might even wonder what would happen if the experiments had been carried to rather higher speeds.

Before comparing those results with some of his own, it was necessary to say a word about the method of measuring durability. Durability was measured commonly in two ways; either by time or by output. It was a matter of convenience entirely which method was adopted, but the results had rather a different appearance according to which method was used. It was a matter of the language into which they were translated, because if the cutting speed was reduced the life of the tool might be increased, and that appeared in the time measurement as a pure gain. But in reducing the speed the rate of output was also reduced, and that reduction in the rate of output might neutralise the increased life. It was necessary to make that remark, because he had adopted himself the output measurement of durability, while the author had adopted the time measurement of durability.

He had replotted Fig. 74 of the paper in terms of output durability, i.e., each observation was reduced in proportion to the cutting speed, although those were proportional to the output obtained at each observation. He had done this to test the validity of the remarkable results, as they were called in the paper, put forward by the Herbert testing machine, and he thought it would be of interest to show exactly what those remarkable results were. The Herbert testing machine was merely a vertical lathe on which a cutting test was made on a tube of 60-ton steel with a very fine cut. The depth of cut was about ·001 in., the thickness of the tube wall on which the tool worked was one-sixteenth of an inch. It was a hard steel, and the durability was measured by the inches of tube turned away. The remarkable results to which the author referred were the following: At a low cutting speed of the order of 20 ft. a minute the durability was exceedingly low, but as the speed was increased the durability increased up to in that case a maximum of 70 ft., and then it fell away.

That was a remarkable result, which the author of the paper apparently set out to examine, and in order that it might be seen exactly what bearing the present paper had on that result he had plotted the author's results on to his diagram, and found they fell in with it almost exactly and showed that below the low speed at which he worked, between 20 ft. and 27 ft., there was a very slight rise in durability. With regard to the huge increase of durability at higher speeds, Dr. Ripper and Mr. Burley denied that it existed, but they offered no evidence on the point. There was plenty of evidence that such an increase did actually take place, both from his own and other shops and from the laboratory. He would not trouble the members with much evidence on the point, but he desired to place two cases before them. One was the evidence of Mr. S. N. Brayshaw, of Manchester, who, in commenting on a paper entitled "The Influence of Heat on Hardened Tool Steels, with Special Reference to the Heat Generated in Cutting Operations," read before the Iron and Steel Institute in 1912, wrote as follows: "The following might serve as an actual example of what occurred in

his own works. A large quantity of tool steel bars ¾ in. diameter were being turned up, and for some time the machines ran at 195 revolutions per minute, which gave a cutting speed of 38 ft. per minute on the largest diameter. The tools dulled very quickly, and had to be resharpened on an average once every 45 minutes. The speed was then increased to 330 revolutions per minute, giving a cutting speed of 65 ft. per minute, other conditions remaining the same. The consequence was that the life of the tools was increased to about three hours, which meant an increase of nearly sevenfold in the actual work done by the tool for every sharpening." The second was the case of a testing machine installed at an arsenal near Paris, on which a very elaborate series of experiments had been made on the testing machine and the lathe side by side, in order to obtain a correlation between the results obtained on the two machines. The replotted curve from Mr. Burley's observations again fitted in with the other results and gave the curious upturn of the curve at the beginning, showing an increase of durability for very low speeds. He had not been able to find this upturn of the curve, but the Paris experiments confirmed it. He did not think it was of any practical importance.

Mr. Dempster Smith remarked that Mr. Burley had, in the first part of the paper, confined his attention to finishing cuts. He had adopted the same methods of measurement as used in experiments carried out at Manchester and reported in the "Proceedings" of the Manchester Association of Engineers in 1914. In those experiments it was sought to find, firstly, what cutting speeds could be worked, and for what length of time, without the tool plucking. They found that at low speeds —in the nature of 10 ft.—per minute, the surface was smooth and bright. As the speed of cutting increased, the surface continued to be smooth for a certain length of time, until a speed of about 60 ft. per minute was reached, when the surface remained smooth, but dull, as if sandblasted. Speaking from memory, he said the enquiry indicated that maximum surface was machined without plucking, at about 60 ft. per minute. The next endeavour had been to obtain a measure of the durability of the tool having regard to blunting. It was found that the surface could be machined up to 180 sq. in. at 10 ft. a minute. The experiments had not been made with the idea of using the tools as finishing tools, but with the object of applying the results to reamers, taps and tools required for fine cutting. The speaker considered that had the author continued his enquiry further, until the critical point referred to by Mr. Herbert had been reached, he would have altered the opinion he had expressed.

The Manchester Steel Tool Committee had adopted the same shape of tool as the author, but for different reasons. With regard to the slight increase in the cubic inches of metal removed with increase of rake angle up to 25 deg., followed by a rapid fall, the decrease was so rapid that the speaker would imagine that the tool must have slipped. Mr. Dempster Smith then referred to a paper, entitled "Lathe Tool Dynamometer Experiments," by Dr. Nicholson and himself, read, in 1906, before the Joint Meeting of the American Society of Mechanical Engineers and the Institution of Mechanical Engineers. The results recorded showed that the cutting force decreased until an angle of 60 deg. was reached, when, for some peculiar reason, it went up. As a matter of fact, it had not been realised that the point had been snipped off just as the tool was entering the metal.

Referring to Fig. 79 of the paper, the speaker remarked that if the diagonal line were produced it would cut the base at a side rake of about 65 deg. For a material having a tensile strength of about 60 tons to 65 tons, and for a steel—such as chrome or nickel-chrome steel—having a tensile strength in the neighbourhood of 90 tons, there should be a negative angle of 19 deg. to 20 deg. He did not think the author intended his line to be carried to that point, but whatever modification was made in the graph would affect Fig. 80 of the paper. The speaker contended that Mr. Burley had adduced no evidence of his assumption that the most durable angle for a high-speed steel was also that for carbon steel; it was hardly to be expected that the same angle would be suitable for both steels. What evidence was there that the gain on all cuts was equal to 50 per cent. in the case of carbon steel?

With regard to the colour of the shaving, in addition to the factors mentioned by the author there was also the relation of cut to traverse, the material being cut, the surface of the tool, &c., all affecting the colour. Fig. 81 of the paper showed decrease of horse-power with increase of side rake, and that result was in accord with what Dr. Nicholson had shown in 1906, and was re-stated in papers read before the Manchester Association of Engineers in 1911 and in 1914; also, he believed, in a paper read before the Institution of Mechanical Engineers about 1909.

The author had, apparently, made no mention in the paper of nose radius, beyond a reference to the fact that the cutting edges of the tools were of the same geometrical shape, the nose radius in each case being proportional to the sectional dimensions. He wished to point out that the phenomenal results obtained by the author were not due, at all events in their entirety, to the section of the steel, but to nose radius and section combined. In Table 8, Mr. Burley had shown that on a ratio of 1: 6 in variation of section of tool, he obtained an increase of 50 per cent. in one cut; whereas, with a variation in nose radius on a ratio of 1 : 2 an increase of 10 per cent. to 23 per cent. was obtained. The effect due to the nose radius was three times that due to the section. Table 9 in the paper showed that there was little in the section of the tool, but a fair amount in the nose radius—about 44 per cent to 47 per cent. The nose radius was the most important factor of the two, a point which the author had not brought out.

Colonel Crompton was the next speaker. He regarded the paper as, in a sense, a dangerous one, by reason of its tendency to lead to false conclusions. It was an age of high-speed steel, and since dividends were paid by mass production the speed at which material could be removed became important, certainly in a great many cases. After commenting humorously upon the reference made by the daily Press to a "wonderful new steel," Colonel Crompton stated that he had been connected with experimental work, initiated by the late Sir Frederick Donaldson, on the distortion of steel in hardening, resulting in errors in screw pitches, which affect interchangeability. He had worked for fourteen years on this question, and had acquired dexterity. It was small-scale work calling for the use of a precision lathe. In carrying out this work he had, up to a certain extent, succeeded in producing a formula for non-distorting steel, but he required a standard of cutting. Investigation in this direction led him to the opinion that the author was wrong in saying that smoothness and finish of surface was limited to such low speeds as 38 ft. a minute. What the speaker had found in the course of laboratory work was confirmed by the large-scale practice of Mr. Vernon, and this fact emboldened him to say that there were high speeds at which more cylindrical and truer work was produced than at the lower speeds. Using steel which contained cobalt as a steadying agent, in addition to molybdenum, and cutting difficult steels with about 4 per cent. of nickel and a percentage of chromium, one sample steel containing 0·4 per cent. of carbon, 4 per cent. of nickel, 1 per cent. of chromium and 0·8 per cent. of manganese—a steel worse than any of the plain high-carbon tool steels having 1·3 per cent. of carbon in them—he had been able to produce a splendid surface, almost equal to that of grinding, at 180 ft. per minute. Under the microscope the bar showed a very fine thread, but very shallow, which could not be felt by the hand; it was, indeed, so shallow that it could be rubbed away with emery paper.

One advantage of working to a small scale, Colonel Crompton remarked, was that he was able to corroborate Mr. Vernon's observation that the power was apparently independent of the speed; not, of course, the power multiplied by the length of shafting, but the actual torque required seemed to be constant, whether the speed were 30 ft. a minute or 200 ft. In arriving at this conclusion, Colonel Crompton had used a very delicate ammeter in circuit. He might point out that the limiting factor in using very high speed was not the tool, but the avoidance of chatter, and on this point the author had been disappointingly silent.

In conclusion, he desired to refer to the loss sustained by the late Mr. J. H. Wicksteed, who had been a personal friend of his and had taught him a great deal of the mechanical engineering he knew. He felt his loss very greatly.

Mr. G. W. Burley expressed his intention of replying to the discussion in writing, and would therefore be contented with remarking that he had not expected that everyone would be in agreement with all that was stated in the paper. The small compass of the latter prevented the inclusion of many points, and the question of chatter was one that he had purposely left out. He would act on Dr. Ripper's suggestion and get out a table of speeds. This he would include in his written reply to the discussion.

The Chairman then announced that Mr. Burley's paper would be also read and discussed at Manchester on Tuesday, the 23rd inst; at Birmingham on Thursday, January 1 next, and at Sheffield on Monday, January 5. The next ordinary meeting of the Institution would be held on Friday, January 23 next, when a paper entitled "Recent Advances in the Utilisation of Water Power" would be read and discussed. The proceedings then closed.

THE PHYSICAL SOCIETY AND OPTICAL SOCIETY'S ANNUAL EXHIBITION.—This exhibition, which is to be held on Wednesday and Thursday, January 7 and 8, 1920, at the Imperial College of Science, South Kensington, will be open in both the afternoon (from 3 p.m. to 6 p.m.) and in the evening (from 7 p.m. to 10 p.m.). Professor F. J. Cheshire, C.B.E., will give a discourse on "Some Polarisation Experiments" at 8 p.m. on January 7, and at 4 p.m. on January 8, and Professor A. O. Rankine, D.Sc., will give a discourse on "The Use of Light in the Transmission and Reproduction of Speech," at 4 p.m. on January 7 and at 8 p.m. on January 8. The lectures will be illustrated by experiments. Some 40 firms will be exhibiting. Invitations have been given to the Institution of Electrical Engineers, the Institution of Mechanical Engineers, the Faraday Society, the Wireless Society of London and the Röntgen Society. Admission in all cases will be by ticket only, and members of the societies just mentioned, including also the Physical and Optical Societies, desiring to attend the exhibition should apply to the secretary of the society to which they belong. Others interested should apply direct to the Secretary of the Physical Society, National Physical Laboratory, Teddington, S.W.

LLOYD'S REGISTRY IN FRANCE.—Lloyd's Register has made developments of much interest and importance in France, where the society is fully recognised under the Shipping Law of 1908. A few months ago, the committee, after assuring themselves that such a step would be favourably viewed by the French shipping community, decided to establish an office in Paris adequately staffed to enable plans of new vessels to be discussed with parties interested, and approved on the spot for Lloyd's classification if they were in accordance with the society's rules. During the war, the French Chantiers were employed almost exclusively on the production of munitions, but great advances in shipbuilding are now to be looked for in France as soon as the present obstacles to progress, principally want of material and skilled labour, have been overcome. Lloyd's Register has been conducted for the last eighty-five years on the basis that the entire control should be in the hands of representatives of the main sections of the shipping community working together on one board of administration for a common end—security at sea—and the application of this representative principle has been extended to the society's operations in France by the establishment of a Comite Francais du Lloyd's Register. The membership includes, as far as the necessary limitation of numbers permits, the names of the leading shipowners, underwriters and shipbuilders of France—most of them well known in all maritime countries: *Shipowners.*—G. Broton, Cie. des Chargeurs Reunis; J. Dal Piaz, Cie. Gen. Transatlantique; Hubert Giraud, Soc. Gen. de Transports Maritimes a Vapeur; A. Grosos, Cie. Havraise Peninsulaire de Nav. a Vapeur; Paul Houet, Soc. Navale de l'Ouest; L. Marechal, Soc. Nationale d'Affretements; D. Perouse, Chargeurs Reunis (President du Comite Contral des Armateurs de France); G. Philippar, Cie. des Messageries Maritimes; J. Stern, Soc. Les Affreteurs Reunis. *Underwriters.*—M. Beraud-Villars (*La Minerve*), President du Comite des Assureurs Maritimes de Paris; U. Bocquet, Comptoir Maritime; L. Gaumont, Union Maritime; A. Seris, La Fonciere; R. Sibilat, La Reunion Française, President du Syndicat de Cies. Francaises d'Assurances. *Builders.*—J. D'Allest, Chantiers et Ateliers de Provence; Ch. Dumont, Ateliers et Chantiers Maritimes du Sud-Ouest, Lloyd de France; F. Godard, Chantiers et Ateliers de St. Nazaire; F. Moritz, Forges et Chantiers de la Mediterranee; F. Ziegel, Chantiers Navals Francais The constitution of such a committee is itself a tribute to the international reputation of Lloyd's Register.

THE "RESTUCCI" TUBE SCRAPER.

We illustrate herewith a new form of tube scraper made and sold by Messrs. Vickers, Limited, of Vickers' House, Broadway, Westminster, London, S.W. 1, and known as the "Restucci" scraper. Figs. 1 and 2 are, respectively, a longitudinal section and end elevation of a scraper suitable for boiler tubes, while similar drawings of a scraper for condenser tubes are reproduced in Figs. 3 and 4. The body of the boiler-tube scraper is turned from a solid bar of mild steel, and formed with three flanges, as shown in Fig. 1. In each of the spaces between the flanges a pair of flat blades, or cutters, of hardened steel is fitted, and the outer edges of these blades are formed with knife edges. The two pairs of blades are arranged at right angles so as to "break joint" as shown in Fig. 2. They are pressed radially outwards into contact with the inner surface of the tube being cleaned, by steel wire springs of hairpin form, which lie in slots in the flanges and pass through holes in the blades. Pressed steel caps are fitted over each of the end flanges for the purpose of retaining the ends of the springs and so limiting the outward movement of the blades. The caps themselves are kept in position by split pins, which can be easily removed if it is desired to take out the blades. At each end of the scraper body is a swivelling ball, the main object of which is to keep the tool central when working in a bent tube. The balls, which are drop-forgings, have eyes formed on them to which cords are attached to enable the scraper to be pulled through a tube of a water-tube boiler, in either direction, by two men—one working from each drum.

The only parts of the tool which require attention from the user are the blades and the springs. The former, being flat plates, are easily sharpened when necessary, and the springs, being of extremely simple form, can be readily exchanged for others giving lighter or heavier pressure according to requirements. The clearance at the back of the cutters, the makers claim, is such that clogging is not likely to occur, but if any trouble is experienced in this respect it can be remedied by washing the complete tool with paraffin, without taking it to pieces. Another important claim for these scrapers is that they will clean a tube bent to a small radius as effectively as a straight tube. They are made for all sizes of tubes up to, and including, 2-in. bore.

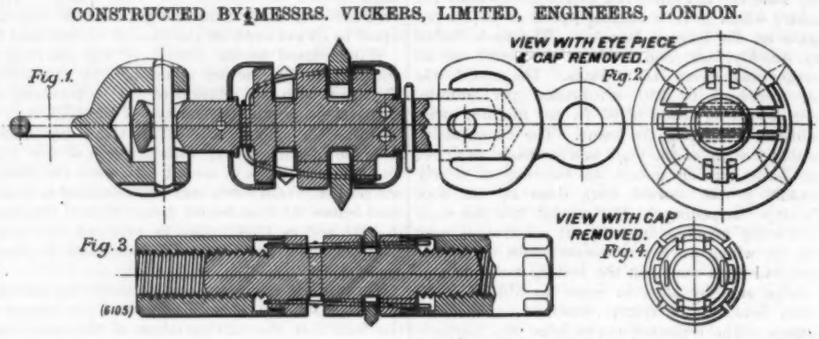
The condenser tube scraper illustrated in Figs. 3 and 4 is similar in principle to that described above, the main difference being the omission of the swivelling balls, which are rendered unnecessary by the fact that the condenser tubes are straight. The pressed steel cap employed in the boiler-tube scraper to retain the ends of the springs, is replaced by a screwed sleeve of tool steel, having an extension which fits over the flange, as shown in Fig. 3, and thus answers the same purpose. The condenser-tube scraper can be screwed on to a rod and operated by one man. Two sizes, for $\frac{5}{8}$-in. and $\frac{3}{4}$-in. tubes respectively, are made.

Ministry of Shipping.—The Prime Minister and the Shipping Controller have consented to the release from the end of the present month of the Right Hon. Lord Pirrie, K.P., from his office as Controller-General of Merchant Shipbuilding, to which he was appointed by the Prime Minister in March, 1918. The Department of the Controller-General has now been completely demobilised, and the permanent elements of the work carried out by Lord Pirrie's Department have been handed back to the appropriate permanent Government Departments. A small number of technical officers and clerks engaged on the economical liquidation of contracts made during the war have been merged with the staff of the Ministry of Shipping.

Foster's Pocket Reference Books.—We have received from Mrs. F. Foster three pocket reference books compiled by her late husband, dealing respectively with Mechanical Engineering, Iron and Steel Works, and Foundry Work. They measure 5$\frac{1}{2}$ in. by 4 in., and contain each much over 100 pages of information on the subjects dealt with. Each gives conversion data, standards, gauge figures, &c. They contain, further, a large amount of information for the use of engineers and metallurgists. The one on iron and steel works, for example, has 140 pages of particulars and figures on coke ovens and their working, on the composition of iron ores, blast-furnace proportions, blast-furnace practice, steel making by the various processes, rolling mills, power plants, the figures covering fuel consumption, heat values, efficiencies, &c. The publication will be found a most handy one for reference purposes and is to be warmly recommended. The price of each book is 2*s.* net. They can be obtained on application to 98, College-road, Whalley Range, Manchester. The author, Mr. Frank Foster, M.Sc., was a member of the Iron and Steel Institute. He took part, it will be remembered, in the discussion on "Fuel Control in Metallurgical Furnaces" at the last September meeting of the Institute (see page 405 *ante*); he died on his return home a few days later.

THE RESTUCCI TUBE SCRAPER.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, ENGINEERS, LONDON.



GAS ENGINES.

To the Editor of Engineering.

Sir,—On reading in your columns, issue of September 26 last, page 404, the report on the discussion of Sir R. Hadfield's and Mr. Sargant's papers at the last meeting of the Iron and Steel Institute, we remarked a statement by Mr. B. Talbot that the first seven gas engines put down by his firm, and supplied by ourselves had been "scrapped" before the war; that afterwards the same firm put down a second type of engine, which was also scrapped, and that they were now busy on a third series of engines from which it was hoped to obtain better results. The perusal of this report might leave the impression, that the two first series of gas engines referred to, had all been supplied by the Société John Cockerill. This is not the case, and we wish it to be clearly understood.

Mr. Talbot's firm was amongst the first to use gas engines in the manufacture of iron and steel. They deserve great credit for the courage and enterprise displayed in adopting what was at the time a complete and almost untried novelty, and of which the results in the field of fuel economy may be fairly described as revolutionary. It is not to be wondered at therefore, if the engines supplied to this firm, by our English licensee in 1905, became promptly the object of numerous improvements, resulting from acquired experience and necessary to an indispensable bringing up to date. This type of engine, consequently, became rapidly obsolete. The units were none the less, as single-acting engine capable of doing good service, for the two first built were still at Seraing in 1914, and were broken up by the Germans when they decided on systematically destroying a great deal of our plant.

From the year 1903 onward the Société John Cockerill adopted exclusively the double-acting type. The principle of constant compression was introduced, and the valve gearing worked out in 1903, was on the whole, so satisfactory that it was retained until the outbreak of the late war, a fact worthy of remark in a branch of design which has been subject to so many alterations and improvements.

The more recent changes in the design of gas engines introduced by the Société John Cockerill have been mostly in the way of simplicity and reduction of the number of parts.

Finally a radical change in the type has been made by getting rid of the crankshaft and using a straight shaft, with overhung cranks. As a consequence we are able to suppress one outside bearing, the shaft turning in two bearings only which can always be kept in line. This is the arrangement adopted by American makers in all their large engines for many years. The most powerful engine built hitherto, for electric-power work, by the Société John Cockerill, is a double-tandem, double-acting engine of the latest type, developing 8,000 h.p. in our own central station. All the gas engines built by the Société John Cockerill since 1903 are still at work. They represent a total of 186,000 h.p. This is not a bad record, when it is remembered that it covers a period of five years stagnation caused by the war.

Yours sincerely,
(Signed) Léon Greiner,
Directeur-Général de la Société Anonyme John Cockerill, Seraing (Belgique).

DISC WHEELS FOR MOTOR CARS.

To the Editor of Engineering.

Sir,—The letter on page 822, by "Motorist," raises the subjects of rigidity, unsprung weight ratio, resilience and efficiency of the various types of wheels used on road vehicles.

Paragraph 3 states that wire wheels run more smoothly than the more rigid types. I doubt if anyone riding in a car can tell the wheels fitted to the particular vehicle by the smoothness, even if the tyres are identical in make, condition and air pressure.

There is room to believe that extreme rigidity of wheel structure is more efficient than a flexible wheel, but if the latter is resilient and made of elastic material, say spring steel, one would expect smoother running. Such a wheel has not however materialised for the stresses in a wheel are not merely radial. Those of us who have raced on push-bicycles know that for a given machine, condition, tyres, &c., the tighter the wire-wheel is strung the faster is the bike. Nothing resists a stress unless it yields in doing so; rigidity is but a relative term.

The wire wheel works and wears, and is extremely awkward to clean. The wire wheel worn allows considerable movement of the hub relative to the rim. The collapse laterally of the wire wheels first produced led to the realisation of the magnitude of the lateral stresses in a wheel, so great as even to approach those due to sideslipping at moderate speed into contact with a kerb.

For given rigidity and elasticity, I favour the lighter wheel, for the very same reasons that I favour the lightest axles or, more correctly, the minimum of unsprung weight on the tyres. I will try to explain.

Consider a wheel (or an axle) striking a projection in the road surface, a projection not wholly absorbable by the tyre, the effect is to force the wheel in an upward direction with a velocity, for a given tyre, more or less proportional to the car speed. The energy in this wheel is the product of the mass multiplied by the velocity squared, and has to be absorbed by the carriage spring, not only so, but, this wheel (or axle) has to be forced down again by the said spring assisted by gravity. It will therefore be seen that the greater the mass of the wheel (or an axle) relative to the mass above the springs the greater will be the upward displacement of the body.

My experience and experiments tend to prove that enormous improvement of the suspensions is derivable by reducing the unsprung masses. The want of space and time prevent me entering now further into this subject; for instance, I have not mentioned the interconnection of the spring and lateral movements.

Obviously the wire wheel is a suspension wheel, and probably the lighter disc wheel will also be a suspension wheel, but, up to the present, and particularly the "Goodyear," they are compression rather than suspension wheels.

Faithfully yours,
A. E. Parnacott, M.I.A.E.
Penge-lane, Penge, S.E. 20, December 20, 1919.

The Westinghouse Automatic Brake.—A small pamphlet issued by the Westinghouse Brake Company, Limited, 82, York-road, King's Cross, London, N. 1, gives illustrated descriptions of the Westinghouse automatic brake, and of its working. It forms a very complete compendium of instructions which will be found of great assistance by all engaged in the working of railway traffic.

Sound Propagation from Aeroplanes.—The distance to which aeroplanes are heard and the character of the sound vary greatly with the atmospheric conditions, but the nature of the conditions is little understood. In a "poor listening" atmosphere little more than the lowest notes are heard; in quiet nights the notes of lower frequency are cut off, and the sharp cracking sounds of the explosions are most distinct. In the latter case particularly, it would appear from experiments made by G. W. Stewart, of Iowa University (*Physical Review*, October, 1919), the characteristics of audition are probably of more importance than the atmospheric conditions. The sense of loudness is not the same for different frequencies, whether the intensities be measured in terms of mechanical units or in terms of minimum audibility. Referring to experiments conducted by Sabine at Harvard University, in 1910, Stewart points out that two sounds of frequencies 64 and 1,024 would appear of equal loudness when the former is 7×10^4, times, and the latter 15×10^6, times its own minimum audible intensity. Of two such sounds appearing of equal intensity to a listener close to the source, the lower note would first cease to be heard with increasing distance from the source, because its intensity would soon sink below the minimum audible limit. Sounds of about 1,024 vibrations per second seemed to carry farthest to the unaided ear. With the aid of simple listening devices Stewart increased the audibility range to 10 times the range of the unaided ear in quiet nights when there was practically no temperature gradient near the ground, which was the open prairie covered with grass. On sunny days, when cumulus was forming, the instrument only doubled the range of audibility of an aeroplane at 1,000 yards elevation, and in disturbed atmosphere the decay of the sound from the aeroplane was very rapid. But even in a quiet atmosphere the transmission of sounds from a considerable height to the earth is very irregular, owing to local variations in the atmosphere.

CUTTING POWER OF LATHE TURNING TOOLS.*

PART II.†

(BEING AN ACCOUNT OF FURTHER EXPERIMENTS MADE IN THE MACHINE-TOOL LABORATORY OF THE UNIVERSITY OF SHEFFIELD.)

By GEORGE W. BURLEY, WH. EX., *of the University of Sheffield, Associate Member.*

INTRODUCTION.

THE present paper, the presentation of which has been delayed on account of the War, constitutes the second part of the paper† on "Cutting Power of Lathe Turning Tools," which was read before the Institution in November, 1913, by Professor W. Ripper, D.Eng., D.Sc., and the present Author. It deals with a continuation of the series of experiments made with lathe turning tools, working on steel, described in the original paper, and in it, amongst the matters dealt with, are a number of points which were raised during the discussion on that paper.

The following points relating to the question of the cutting qualities and efficiency of lathe turning tools when working on steel are considered in the sequence given :—

1. The relation between the cutting speed and the degree of finish obtained by the use of ordinary lathe finishing and light-cutting tools.
2. The relation between the cutting speed and the durability of ordinary lathe finishing and light-cutting tools.
3. The influence of different rake angles upon the cutting power of high-speed lathe roughing tools.
4. The relation between the rake angles of high-speed lathe roughing tools and the power consumed in cutting.
5. The influence of the nose-radius and that of the cross-sectional area of the tool steel upon the cutting qualities of lathe roughing tools.
6. The influence of the height of the cutting edge upon the cutting efficiency of high-speed roughing tools.
7. The influence of the forging operation on the nose of a lathe turning tool upon the cutting power of the tool.
8. The influence of the direction and active length of the cutting edge of a high-speed lathe roughing tool upon the net amount of power consumed in cutting.
9. The relation between the cutting speed and the net amount of energy required to remove a cubic inch of steel by means of a high-speed turning tool.
10. The relation between the use of cooling agents in turning operations and the cutting power of high-speed turning tools.
11. The influence of cooling agents upon the net power consumption when high-speed turning tools are employed.
12. The condition of the cutting edge of a lathe turning tool with respect to the cutting efficiency of the tool.

Each one of the tests herein described was made on one or other of the two lathes already described in the original paper; the tests which involved roughing cuts, tools of large sections, and power measurements being made on the large electrically-driven experimental lathe; whilst those involving finishing cuts were made on the small lathe fitted with a variable-speed mechanism. Further, the materials on which these experiments were made were identical with those used in the original sets of experiments.

1.—RELATION BETWEEN CUTTING SPEED AND CHARACTER OF SURFACE FORMED BY FINISHING TOOL.

One of the principal objects of the experimental work outlined in the first paper was to determine whether the remarkable results‡ in connection with the durability of cutting tools which are obtained on the "Herbert" tool-testing machine are comparable with the results of tests on tools in the lathe under conditions conforming to those which operate in ordinary lathe practice. It was shown that, with both plain-carbon and high-speed steel tools working under ordinary cutting-tool conditions with cuts which, for the sections of the tools experimented with, could be classed as roughing cuts, no results similar to those of the "Herbert" test were obtainable.

To cover a still wider field in connection with this matter, a continuation of the research has been made with tools working under very light finishing-cut conditions in contrast with the conditions of the original research.

Tool Steels.—The tools employed in these tests were made variously of three varieties of tool-steel, as under :—

(*a*) Plain carbon tool-steel, containing about 1·3 per cent of carbon ;
(*b*) Ordinary high-speed tool-steel, containing about 14 per cent. of tungsten ;
(*c*) Superior high-speed tool-steel, containing about 18 per cent of tungsten and about 0·75 per cent. of vanadium.

Test-Bars.—The tools were tested on steel bars of two qualities, namely, mild steel and very hard steel, the chemical compositions and physical properties of these steels being given in Appendix VII and VIII (page 875) respectively under the letters W and Z. These bars were initially about 2 ft. 6 in. in length and 6 in. in diameter.

Tools.—The tools used in the tests were made from bars ¾ in. by ½ in. in section, and were about 12 in. long. The shapes of tool-nose and the angles adopted are represented in Figs. 68 and 69, the former indicating the shape and angles of the tools tested on the mild steel, and the latter those of the tools tested on the hard-steel bar. The cutting edge of each tool was ground to a very large radius, with a front rake angle of 20 deg. and 10 deg. for the soft and hard bars respectively, and a uniform front clearance angle of 5 deg., there being no side rake or side-clearance ground on the tools.

Fig. 68. FINISHING TOOL FOR MILD STEEL.

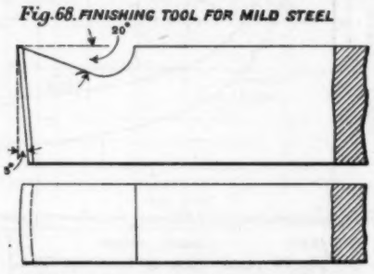


Fig. 69. FINISHING TOOL FOR HARD STEEL.

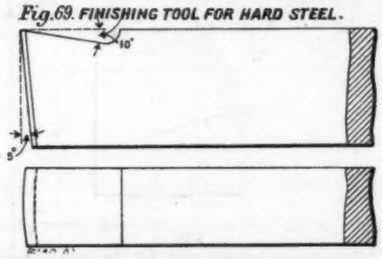


Fig. 70. TEST BAR FOR FINISHING-TOOL TESTS.

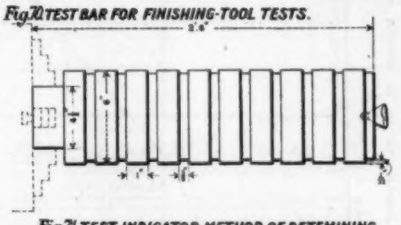
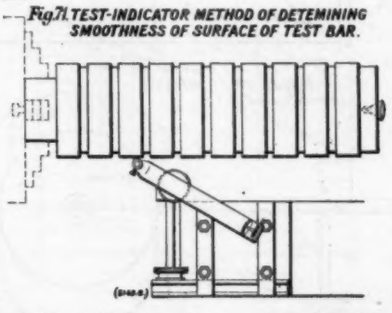


Fig. 71. TEST-INDICATOR METHOD OF DETEMINING SMOOTHNESS OF SURFACE OF TEST BAR.



Standard of Test.—The degree of smoothness or finish of the surface of the test-bar formed by each tool was taken as the measure or modulus of the efficiency of that tool, it being assumed that all the finishing tool is useless as such at any cutting speed at which it does not produce a smooth surface. To determine the degree of finish in each case, several methods were experimented with, but since in every case the standard or critical degree of finish had to be based on human judgment it was finally decided to depend, in the first instance solely upon the combination of the independent judgments of a number of experienced observers based upon ordinary visual examination of the surface of the bar.

Method of Testing.—For this set of tests, each test-bar was divided into a number of 1-in. lengths, separated by shallow grooves ¼-in. wide, as indicated in Fig. 70. The *modus operandi* was to take each tool, hardened ground, and oil-stoned ready for use, and to run it on the first inch-length of the test-bar at a definite low cutting speed, with a depth of cut of 0·004-in. and a feed of $\frac{1}{14}$-in. per revolution. It was allowed to traverse the whole inch-length, and was then removed and re-sharpened for the test at a slightly higher cutting speed on the next inch-length. This sequence of operations was repeated for about fourteen different cutting speeds, these ranging from 7 ft. per minute to approximately 125 ft. per minute for each test-bar and for each variety of tool-steel experimented with. The character of the finish produced at each speed by each tool was determined as indicated above, and the whole object of these tests was the determination of the manner in which the cutting speed affected the quality of the work done by lathe finishing tools, and especially of any critical cutting speed or speeds which might exist for this type of tool.

Test Results.—The final results of these are given in Tables 1 and 2 (pages 867 and 868), the former covering the tests on the mild-steel bars, and the latter those on the hard-steel bars. It should be noted that, in every case, these tests were made under ordinary finishing-cut conditions, including the use of a cooling and lubricating agent (diluted soluble-oil compound) and a cutting-edge trail equal to one-half the feed, so as to make the results as applicable to ordinary practice as possible.

In these Tables (x) indicates the cutting speed at which the phenomenon of building up on the cutting edge of the tool was observed to be marked under each set of conditions. Probably, the presence of the built-up edge accounts for the formation of the rough, torn surface in each instance.

An examination of these results will show that there is practically no minimum limiting or critical cutting speed, at below which finish-turning operations cannot be satisfactorily performed since, though the lowest cutting speed employed in these tests was 7 ft. per minute, the degree of finish obtained at this speed was not inferior to that obtained at any one of the higher speeds, whilst cutting speeds below this are of little significance from the ordinary workshop view-point.

In regard to the question of the maximum limiting cutting speed for finishing cuts, it will be seen that, for the mild-steel bar, this is in the vicinity of 48 ft. per minute for each of three kinds of tool-steel experimented with; whilst, for the hard-steel bar, it varies from 17 ft. per minute for the ordinary oil-hardening variety of high-speed tool-steel to 28 ft. per minute for the water-hardening variety of high-speed tool-steel, plain carbon tool-steel being intermediate to these. Above these respective speeds the tools did not produce surfaces which would pass any acceptable visual test for smoothness, and no evidence could be obtained to show that cutting speeds above these respective limits are suitable for finish-turning operations.

Quantitative Test Methods.—As a check upon the results of the above tests, and to determine, if possible, a quantitative measure of the degree of smoothness of the surface formed at each cutting speed, several of the test methods were experimented with, the most successful being the test-indicator method. The method of using the indicator is indicated in Fig. 71, annexed, the instrument being held in the tool-holder of the lathe slide-rest and moved along like the tool after the latter had formed the surface. The contact finger of the indicator was placed in contact with the tooled surface of the test-bar, and the maximum variation of the readings of the indicator was observed whilst the latter was traversed from end to end of each inch-length of the bar. This variation was obtained for each of a number of places in the circumference of the bar for each inch-length, and the average maximum variation so obtained for each length was taken as a measure of the general roughness of the surface of that length.

TABLES 1A–1C.—*Results of Finishing cut Tests on Mild Steel Test-Bar, W., with Lubricant-coolant.*

Depth of Cut = 0·004-in. Feed per Revolution of Bar = $\frac{1}{14}$-in.

1A.—Plain Carbon Tool-Steel.		1B.—Ordinary High speed Tool-Steel.		1C.—Superior High-speed Tool-Steel.	
Cutting Speed.	Character of Finish obtained on Surface of Test-Bar.	Cutting Speed.	Character of Finish obtained on Surface of Test-Bar.	Cutting Speed.	Character of Finish obtained on Surface of Test-Bar.
ft. per min.		ft. per min.		ft. per min.	
7	Smooth	7	Smooth	7	Smooth
10	Smooth	11	Smooth	12	Smooth
15	Smooth	15	Smooth	17	Smooth
20	Smooth	20	Smooth	22	Smooth
25	Smooth	27	Smooth	28	Smooth
31	Smooth	33	Smooth	33	Smooth
38	Smooth	40	Smooth	41	Smooth
48	Smooth	48	Smooth	48	Smooth
58 (x)	Rough (surface torn)	58 (x)	Rough (surface torn)	58 (x)	Rough (surface torn)
71	Rough (surface torn)	70	Rough (surface torn)	68	Rough (surface torn)
84	Rough (surface torn)	84	Rough (surface torn)	80	Rough (surface torn)
96	Rough (surface torn)	96	Rough (surface torn)	95	Rough (surface torn)
109	Rough (surface torn)	110	Rough (surface torn)		Rough (surface torn)
119	Rough (surface torn)	120	Rough (surface torn)	120	Rough (surface torn)

The conditions under which these tests were made were precisely the same as those of the previous tests, so that the two sets of results are quite comparable. In Table 3 (page 868) the results of the tests with plain carbon steel tools made on the mild-steel test bar are given in tabular form, whilst in Fig. 72 the same results are presented in grapical form. The results of the tests with the ordinary and superior high-speed steel tools on both the mild-steel and hard-steel test bars were similar in character to those here given.

This Table and diagram show that up to a cutting speed of 48 ft. per minute the degree of roughness of the surface formed was practically constant. Between this speed and a cutting speed of 58 ft. per minute, however, there occurred a comparatively sudden change in the character of the surface formed, and this change appeared

* Read before the Institution of Mechanical Engineers, December 19, 1919.

† Part I, Proceedings, I. Mech.E., 1913, Part 4, page 1067, see ENGINEERING, vol. xcvi, page 737.

‡ Proceedings, I.Mech.E., 1913, Part 4, page 1068.

to be maintained regularly as the cutting speed was further increased.

These results confirm the results of the visual-examination tests, and both sets of results indicate that from the standpoint of surface-finish there is no minimum critical cutting speed at below which it is not advisable to work a finish-turning tool.

Several other forms of check tests were tried, but these for various reasons, chiefly connected with the conditions peculiar to the tests themselves, had to be abandoned. The majority of these tests involved the use of small friction brakes, which were used in several different ways. In one of these brake-tests an attempt was made

TABLES 2A–2C.—*Results of Finishing-cut Tests on Hard Steel Test Bar, Z, with Lubricant-coolant.*

Depth of Cut = 0·004-in. Feed per Revolution of Bar = $\frac{1}{14}$-in.

2A.—Plain Carbon Tool-Steel.		2B.—Ordinary High-speed Tool-Steel.		2C.—Superior High-speed Tool-Steel.	
Cutting Speed.	Character of Finish obtained on Surface of Test-Bar.	Cutting Speed.	Character of Finish obtained on Surface of Test-Bar.	Cutting Speed.	Character of Finish obtained on Surface of Test-Bar.
ft. per min.		ft. per min.		ft. per min.	
7	Smooth	7	Smooth	7	Smooth
12	Smooth	12	Smooth	11	Smooth
16	Smooth	17	Smooth	16	Smooth
21	Smooth	21 (x)	Rough (surface torn)	21	Smooth
23	Smooth	24	Rough (surface torn)	28	Smooth
28 (x)	Rough (surface torn)	30	Rough (surface torn)	34 (x)	Rough (surface torn)
33	Rough (surface torn)	38	Rough (surface torn)	42	Rough (surface torn)
38	Rough (surface torn)	48	Rough (surface torn)	54	Rough (surface torn)
54	Rough (surface torn)	58	Rough (surface torn)	66	Rough (surface torn)
64	Rough (surface torn)	71	Rough (surface torn)	78	Rough (surface torn)
76	Rough (surface torn)	86	Rough (surface torn)	89	Rough (surface torn)
86	Rough (surface torn)	100	Rough (surface torn)	101	Rough (surface torn)
97	Rough (surface torn)	114	Rough (surface torn)	115	Rough (surface torn)
106	Rough (surface torn)	124	Rough (surface torn)	128	Rough (surface torn)
116	Rough (surface torn)	—	—	—	—

TABLE 3.—*Lathe Indicator-Tests.*

Plain Carbon Steel Tool on Mild-Steel Bar, W. Depth of Cut = 0·004 inch. Feed = $\frac{1}{14}$-inch per revolution.

Cutting Speed, in ft. per min.	Average Maximum Variation in Indicator Readings.
7	Under 0·00025 in.
10	Under 0·00025 in.
15	Under 0·00025 in.
20	0·00025 in.
25	0·00025 in.
31	0·00025 in.
38	Slightly above 0·00025 in.
48	Slightly above 0·00025 in.
58	0·0010 in.
71	0·0015 in.
84	0·0020 in.
96	0·0025 in.
109	0·0030 in.
119	0·0035 in.

to measure the frictional resistance between the surface of the test-bar and the working surface of the brake, the underlying idea being that the degree of smoothness of the former was related to this resistance. The arrangement of the brake is indicated in Fig. 73. It was found, however, that either the braking action produced a slight and gradual change in the character of the surface under test, or the character of the working surface of the brake (which was made variously of lead, copper, hard cast-iron, and hard wood) underwent a gradual change with the progress of the tests. Furthermore, it was impossible to keep the two surfaces perfectly dry and free from moisture and grease, and so prevent the test results from being influenced by lubrication effects.

Another unsuccessful breaking method had as its basis the time taken by the brake, under a given constant pressure, to move a definite distance (actually 1 in.) longitudinally along the test-bar under the influence of the combination of the rotary motion of the bar and the feed marks left by the tool on the surface of the bar. Here, also, the conditions of the test produced changes in the character of the surface under test, thus vitiating the results.

2.—Relation between Cutting Speed and Durability of Lathe Finishing Tools.

Having obtained the values of the cutting speed at beyond which it was found impossible to obtain a smooth, finished surface on steel, tests were made to determine the relation between the cutting speed and the durability of lathe finishing tools up to the critical or limiting cutting speeds for the several sets of conditions.

In these tests each tool was worked at a number of graduated cutting speeds ranging up to the limiting speed as determined in the previous tests for the respective conditions; and the durability of its cutting edge was determined at each speed, the durability in this case being taken as the time required from the commencement of the cut to blunt the cutting edge of the tool sufficiently to cause it to be pushed away from the test-bar and thus to lose its cut.

Other methods of determining the durability of the tools were tried, these including test-indicator, screw-micrometer, and visual-examination methods; but the first two of these did not work very satisfactorily for a variety of reasons, whilst it was found that, by means of the visual-examination method, it was not possible to decide just when and where a critical change in the character of the tooled surface occurred, though the method was suitable for the purposes of comparison in regard to surfaces unconnected and distinct. All these methods were consequently abandoned in favour of the one described above.

The results of two sets of these tests are indicated in

Fig. 72. Relation between Smoothness of Surface & Cutting Speed.

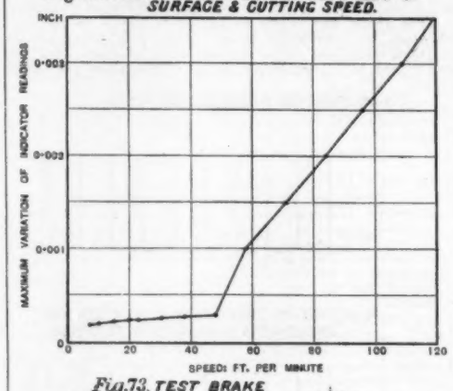
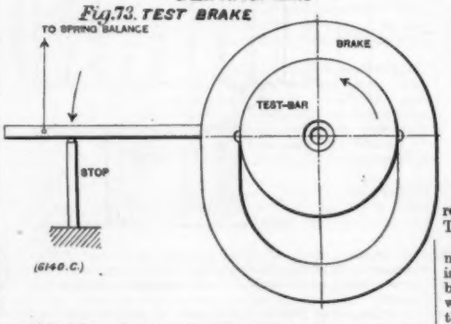


Fig. 73. Test Brake



graphical form in Fig. 74. The sample curves given in this figure represent the relationships between the durability of plain carbon steel finishing tools and high-speed steel finishing tools and the cutting speeds on the hard-steel test-bar, Z, the curves for the other combinations of tool-steel and test-bar steel being similar to these in general character.

It will be noticed that the general form of these curves is somewhat similar to that of the durability curves given in the previous paper* as applying to the case of roughing tools, high durability of the cutting edge being associated with low cutting speed, and *vice versa*; and that there is no decline of durability coinciding with a reduction of the cutting speed, nor an increase of durability coinciding with an increase of the cutting speed.

3.—Influence of Rake Angles of Roughing Tools on Cutting Power.

In the tests described in the previous Paper the tools were all ground to the same angles of rake and clearance so as to reduce the number of variables involved in the work. It was not, however, intended that this should suggest that the angles, particularly of rake, given therein were the most suitable angles to adopt under all circumstances; and further investigations have been made with a view to the determination of the relationship which subsists between the angles of a lathe roughing tool and its cutting power.

These investigations were carried out on the mild-steel, medium-steel, and hard-steel test-bars, A, B, and C respectively, the chemical compositions and physical properties of which are given in Appendixes VII and VIII (page 875).

The tools for this research were made from $\frac{3}{4}$-in. by $\frac{1}{2}$-in. bars of ordinary high-speed tool steel, containing about 14 per cent. of tungsten. The plan-shape of each tool nose is indicated in Fig. 75, the combination of the front and side rake angles being such as to make the cutting edge AB horizontal in every instance. The tools were ground directly from the plain bar, without any preliminary forging, the curvature of the nose, to a radius of $\frac{1}{4}$-inch, being finished off to a template. The combinations of rake angles which were adopted are given in Table 4, the clearance angles accompanying these being 5 deg. for the front of the tool and 4 deg. for the side through the series.

The test which was applied was the "Speed-increment Test"* as devised for the comparative testing of tool steels. The starting speeds in the tests on the different materials were as follows: on mild steel, 80 ft. per minute; on medium steel, 60 ft. per minute; and on hard steel, 30 ft. per minute. The cut adopted for the whole series of tests was $\frac{1}{8}$-in. deep with a feed of $\frac{1}{14}$-in. per revolution.

Three tests were made with each tool on each test-bar, and the average of the results of the three tests in each case was taken as the criterion value for the particular combination of rake angles and test-bar material, this criterion value, which represents the cutting power, being the average volume of metal, in cubic inches, removed from the test-bar up to the point of breakdown of the cutting edge of the tool. The average

Fig. 74. Durability Curves for Finishing Tools.

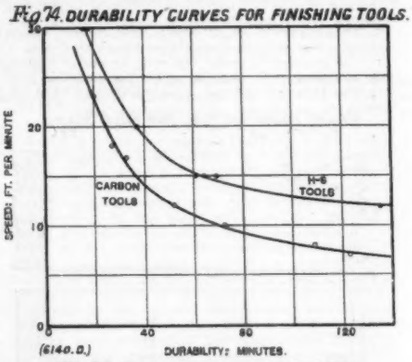
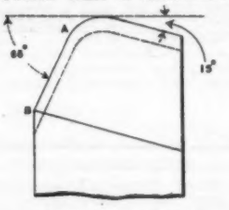


Fig. 75. Plan-View of Roughing Tool.



results of all the tests in this series are set forth in Tables 5A to 5C, on page 869.

These results indicate that, for the machining of the mild-steel bar, the most suitable angle of side rake (that is, the angle of side rake associated with maximum durability and cutting power) lies between 20 deg. and 25 deg., with a corresponding front-rake angle of 10–12 deg., the corresponding angles for the machining of the medium

TABLE 4.—*Rake Angles of Lathe Roughing Tools.*

No. of Tool.	Front Rake Angle.	Side Rake Angle.
	deg.	deg.
1	0	0
2	2½	5
3	4½	10
4	5½	12
5	7	15
6	9½	20
7	12½	25
8	15	30
9	18	35

steel bar being 15–20 deg. and 7–9½ deg. respectively, and for the machining of the hard-steel bar 10 deg. and 4½ deg. respectively.

The curves in Figs. 76–78 illustrate these results graphically, and show (1) that there is a critical angle of sharpness of the nose of the tool for each grade of hardness of the material to be machined; (2) that a slight variation in the value of the angle of rake has a relatively small influence on the durability and cutting power of the tool, provided that the variation is in the nature of a reduction of the value; and (3) that when the critical angle of rake is exceeded there is a very rapid depreciation in the life and cutting qualities of the tool, provided that all the other conditions of working are maintained constant and unvarying.

The relationship between the angle of side rake for the maximum output of the tool (that is, the critical angle of

* Proceedings I.Mech.E., 1913, pages 1081, *et seq.*, and 1096 *et seq.*

* Proceedings, I.Mech.E., 1913, page 1119.

side rake) and the maximum tensile strength of the steel to be machined is indicated in graphical form in Fig. 79, from which it will be seen that the law which connects these two quantities is practically a straight-line law. The equation to the curve is as follows :—

$$R = 40 - 0{\cdot}6\,T, \quad . \quad . \quad . \quad (1)$$

where R = the critical angle of side rake, in degrees, and T = the maximum tensile strength of the steel operated upon, in tons per square inch.

Relating the results of these tests with the test-results recorded in the original paper, we find that the angles of rake adopted throughout the original tests, namely, 23 deg. of side rake and 11 deg. of front rake, are practically those which are the most suitable angles for tools to be used on mild steel, and that the cutting speeds given in that paper for the rough machining of mild steel are, therefore, confirmed. But in the case of the rough-machining of steel of medium and hard qualities, the results already recorded, since they are based upon the condition of constant rake angles for all degrees of hardness of the material to be machined, require to be modified and corrected in view of the above results. This modification is necessary because of the fact that with the most suitable angles of rake in each case the cutting power of a tool is much greater than when the uniform standard angles of 23 deg. and 11 deg. are used.

Fig. 76. EFFECT OF VARIABLE RAKE ANGLES.-MILD STEEL.

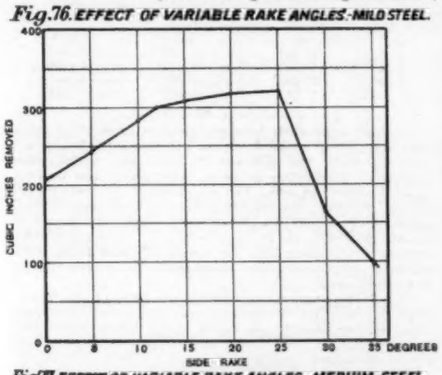
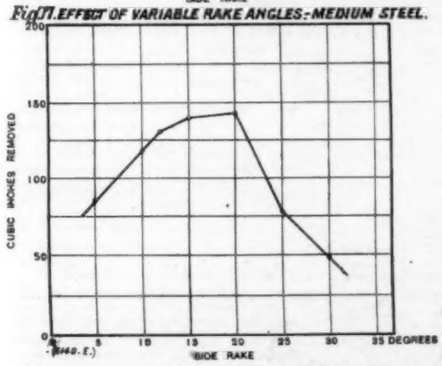


Fig. 77. EFFECT OF VARIABLE RAKE ANGLES.-MEDIUM STEEL.



The necessary modification consists of the introduction into the associated-speed formulæ* of a factor which may be very appropriately described as a "rake coefficient," since it represents the enhancement of the cutting power under the above conditions. This rake coefficient is the ratio of the maximum output (that is the output obtained with the most suitable angles of rake) and the output with the angles of rake adopted in the original tests. The value of this coefficient depends upon the tensile strength of the steel in the test-bar, the relation between these two quantities obeying a straight-line law as is indicated in graphical form in Fig. 80. From this figure it will be seen that the value of the rake coefficient when the tensile strength is 25 tons per square inch is 1·00, and that it is 1·55 when the tensile strength is 50 tons per square inch. The expression which is represented by the curve in this figure is :—

$$C = 0{\cdot}45 + 0{\cdot}022\,T$$
$$= 0{\cdot}022\,(20 + T) \text{ practically}, \quad . \quad (2)$$

where C = the rake coefficient, and T = the tensile strength of the test-bar steel, in tons per square inch.

The associated-speed formula for plain carbon-steel turning tools, assuming the use of the most suitable angles of rake as given in Fig. 79 (above), becomes by the introduction of the above rake coefficient :—

$$S = \frac{0{\cdot}00077\,(67 - T)\,(20 + T)\,\sqrt[4]{a}}{\sqrt{FD}} \quad . \quad (3)$$

The corresponding formula for high-speed steel turning tools is :—

$$S = \frac{0{\cdot}00537\,(65 - T)\,(20 + T)\,\sqrt[6]{a}}{\sqrt[3]{F^2 D}} \quad . \quad (4)$$

In these two formulæ, S = the associated cutting speed, in feet per minute ; T = the tensile strength of the steel to be turned in tons per square inch ; a = the cross-sectional area of the shank of the tool, in square inches, with the nose-radius a function of the cross-section ; F = the feed of the tool per revolution of the work piece ; and D = the depth of cut to be taken by the tool.

The above two formulæ are deduced from the results of tests in which no lubricant or coolant was employed on the tools or test-bars. They, therefore, represent the case of "dry" rough turning. The formulæ for "wet" or "lubricated and cooled" rough turning can be derived from these by applying a correction obtained by averaging the gains of cutting power secured by using a lubricant-coolant as given by the results of tests made later with wet turning. This average gain is practically 50 per cent., so that the associated-speed formula for ordinary carbon-steel turning tools, assuming the use of the most suitable angles of rake, as given in Fig. 79 (below), and the use of an effective lubricant-coolant, is :—

$$S = \frac{0{\cdot}00115\,(67 - T)\,(T + 20)\,\sqrt[4]{a}}{\sqrt{F\,D}} \quad . \quad (5)$$

whilst the corresponding formula for high-speed turning tools is :—

$$S = \frac{0{\cdot}00805\,(65 - T)\,(T + 20)\,\sqrt[6]{a}}{\sqrt[3]{F^2\,D}} \quad . \quad (6)$$

Fig. 78. EFFECT OF VARIABLE RAKE ANGLES. HARD STEEL.

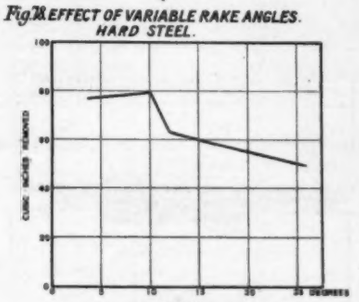


Fig. 79. RELATION BETWEEN MOST SUITABLE SIDE-RAKE ANGLE AND TENSILE STRENGTH OF BAR TURNED.

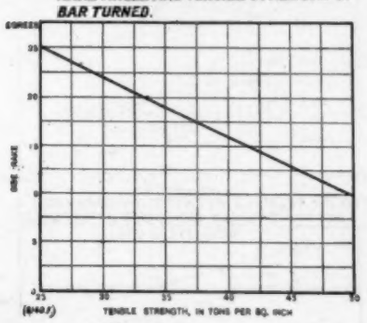
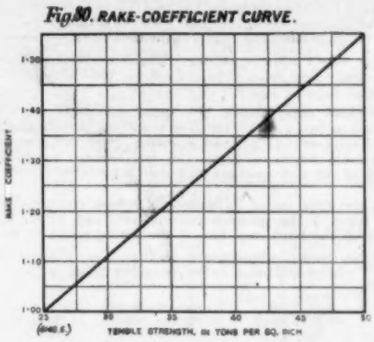


Fig. 80. RAKE-COEFFICIENT CURVE.



These differences are probably due to the fact that the hardness of steel is dependent to a considerable extent upon its carbon content, and that the oxygen of the atmosphere unites more readily with the carbon to produce discolouration in the case of the steel with the higher carbon-content, especially at the higher chip temperatures which are attained in this case. It would, therefore, appear that the colour of the chips formed in a rough-turning operation is not necessarily an index of the condition of maximum cutting efficiency, as is frequently supposed.

4.—Relation between Rake Angles and Power Consumption of Lathe Roughing Tools.

As an addendum to the above tests, an investigation was made into the influence of the angles of rake of a lathe rough-turning tool upon the power actually expended at the cutting edge of the tool in overcoming the cutting resistances. These tests were made with the aforementioned tools (Table 4, Nos. 1–9), on the same test-bars, A, B, C, and with the same area of cut, $\frac{1}{4}$ in. deep by $\frac{1}{12}$ in. feed per revolution, the form of test adopted being the so-called constant-speed test. Each tool was worked at four different cutting speeds, as given in Table 6A–6C, the speed throughout each individual test being maintained as constant as possible. In these Tables, the nett horse-power expended in overcoming the resistances at the cutting edge of the tool is given for each combination of tool, test-bar, and cutting speed, this quantity being the calculated difference between the gross horse-power required to run the lathe against the cut, and the horse-power required to run the lathe with the slide-rest in motion at the same rate of transverse, but without the cut.

These results (which are presented in graphical form in Figs. 81–83, on page 870), show that an increase in the angles of rake is accompanied by a decrease in the nett rate at which energy is consumed at the nose of the tool to overcome the resistance to cutting offered by the material being cut. From this we may draw the deductions that with an increased amount of rake a lathe turning tool cuts more readily and freely, and that there are no critical values of the angles of rake in connection with the nett power consumption as there are in connection with the durability of the cutting edge of such a tool. Thus, whilst a side-rake angle of 10 deg. is associated with the maximum durability of the cutting edge of the tool when hard steel is being turned, it is not associated with either the minimum or the maximum net power-consumption. This also applies to a side-rake angle of 20 deg. for medium-steel turning, as well as to one of 25 deg. for mild-steel turning.

One conclusion which follows directly from this result is that the durability of the cutting edge of a lathe rough-turning tool does not depend solely upon the rate at which heat is generated in the process of cutting ; but also

TABLES 5A–5C.—Rake-angle Tests : Cutting Power of Lathe Roughing Tools.

No. of Tool.	5A.—Speed-increment Tests on Mild-steel Bar, A. Starting Speed 80 ft. per min. Depth of Cut ¼ in. Feed $\frac{1}{12}$ inch per rev.			5B.—Speed-increment Tests on Medium-steel Bar, B. Starting speed 60 ft. per min. Depth of Cut ¼ in. Feed $\frac{1}{12}$ in. per rev.			5C.—Speed-increment Tests on Hard-steel Bar, C. Starting Speed 30 ft. per min. Depth of Cut ¼ in. Feed $\frac{1}{12}$ in. per rev.		
	Average Duration of Test, or Durability of Tool.	Average Volume of Metal Removed by Tool.	Colour of Turning Removed at Beginning of Test.	Average Duration of Test, or Durability of Tool.	Average Volume of Metal Removed by Tool.	Colour of Turning Removed at Beginning of Test.	Average Duration of Test, or Durability of Tool.	Average Volume of Metal Removed by Tool.	Colour of Turning Removed at Beginning of Test.
	min. sec.	cub. in.		min. sec.	cub. in.		min. sec.	cub. in.	
1	20 12	228	Grey	—	—	—	—	—	—
2	21 25	243	Blue	10 28	85	Pale blue	16 22	77·6	Grey
3	24 31	283	Purple	14 7	118	Blue	16 40	79·5	Pale blue
4	25 43	301	Dark brown	15 32	131	Purple	13 47	63·2	Blue
5	26 28	309	Light brown (straw colour)	16 28	140	Dark brown	13 14	69·4	Purple
6	27 0	319	Colour hardly perceptible	16 43	143	Light brown (straw colour)	12 25	55·5	Dark brown
7	27 21	322	Uncoloured	9 37	78	Colour hardly perceptible	11 21	50·2	Light brown (straw colour)
8	15 2	164	Uncoloured	6 5	48	Uncoloured	—	—	—
9	9 12	98	Uncoloured	—	—	—	—	—	—

Another point which these results bring out is that the colour of the turnings which are formed when steel is being machined in the lathe depends upon the degree of hardness of the steel and the rake angles of the tool. Thus, in the case of mild-steel turning, an uncoloured or only faintly coloured cutting is formed when the tool is ground with the most suitable angles of rake ; and with a reduction in these angles the colour of the cutting deepens until a limiting grey is reached. In the case of medium-steel turning the most suitable rake angles are associated with a brown colour of chip ; whilst the corresponding colour in the case of hard-steel turning is a pale blue.

* Proceedings, I. Mech.E., 1913, Part 4, page 1207.

upon the form and general dimensions of the nose of the tool.

5.—Influence of Nose Radius and Tool Section on Cutting Qualities of Lathe Roughing Tools.

In the previous paper,* the results of an investigation on lathe turning tools of different sectional dimensions were given, the object of the investigation being to determine the relation between the output and sectional area of a lathe turning tool under special conditions. In the experiments involved in the investigation, the effect of varying the radius of the cutting edge of the tool was not separated from the effect of varying the section of the shank or body of the tool, since all the tools tested were prepared with cutting edges of the same geometrical shape, the nose-radius in each case being distinctly proportional to the sectional dimensions of the tool.

A further research has since been made with a view to the determination of the individual effect of each of these two factors, and also of their mutual relation, as well as to show whether the cutting efficiency of a lathe roughing tool is dependent at all upon its sectional dimensions.

The tools which were experimented with were made of the ordinary quality of high-speed steel and ground from the plain bar on a universal tool-grinding machine, the sections of the tools ranging from $\frac{1}{2}$ in. square to $1\frac{1}{4}$ in. square as in the previous experiments. The shape of nose adopted for these tools was the one taken as the standard in the original tests, the plan view of which is given in Fig. 75 (page 868), the angles of the tool being as follows :

Top rake, front = 11 deg. Front or heel clearance = 5 deg. Top rake, side = 23 deg. Side clearance = 5 deg.

In these experiments, the speed-increment test was applied in two forms : the first involving a constant life of the tool, or constant test-duration, of 20 minutes with a variable depth of cut ; and the second a constant depth of cut and constant feed with a variable life of the tool.

In the first set of experiments, which embodied the first form of the speed-increment test, and which were made on the hard-steel bar, C, a starting speed of 20 ft.

Tables 6A–6C.—*Rake-angle Tests : Net Power Consumption of Lathe Roughing Tools.*

No. of Tool.	6A.—Tests on Mild-Steel Bar, A. Depth of Cut $\frac{1}{4}$ in. Feed $\frac{1}{75}$ in. per rev.		6B.—Tests on Medium-Steel Bar, B. Depth of Cut $\frac{1}{4}$ in. Feed $\frac{1}{75}$ in. per rev.		6C.—Tests on Hard-Steel Bar, C. Depth of Cut $\frac{1}{4}$ in. Feed $\frac{1}{75}$ in. per rev.	
	Cutting Speed.	Net Horse-power consumed at Nose of Tool.	Cutting Speed.	Net Horse-power consumed at Nose of Tool.	Cutting Speed.	Net Horse-power consumed at Nose of Tool.
	ft. per min.		ft. per min.		ft. per min.	
1		5·58		—		—
2		5·38		1·64		1·92
3		5·17		1·57		1·74
4		4·85		1·50		1·71
5	69·0	4·70	18·0	1·34	19·9	1·58
6		4·63		1·15		1·42
7		4·55		0·98		1·39
8		4·23		0·85		—
9		4·06		—		—
1		5·91		—		—
2		5·71		2·70		2·87
3		5·49		2·54		2·81
4		5·38		2·50		2·74
5	78·0	5·26	33·0	2·38	30·9	2·57
6		5·10		2·22		2·40
7		5·00		2·03		2·23
8		4·61		1·93		—
9		4·31		—		—
1		6·25		—		—
2		6·06		3·72		4·11
3		5·86		3·60		3·87
4		5·74		3·50		3·69
5	89·0	5·54	48·0	3·27	41·0	3·55
6		5·47		3·13		3·41
7		5·31		2·95		3·23
8		5·01		2·80		—
9		4·86		—		—
1		7·11		—		—
2		6·97		4·85		4·62
3		6·53		4·67		4·46
4		6·36		4·60		4·31
5	100·0	6·25	64·0	4·46	46·2	4·00
6		6·10		4·18		3·69
7		5·90		4·03		3·50
8		5·61		3·90		—
9		5·45		—		—

per minute was adopted, and a speed-increment of 1 ft. per minute was applied every minute. With each tool it was found possible to select depths of cut which would give, with a given constant feed, test-durations or tool lives of 20 minutes, slightly more or less ; and the depth of cut which corresponded to the standard tool life of 20 minutes was obtained by interpolation in a curve drawn from the data of a number of such tests and equating the experimental depth of cut with the actual life of the tool.

The results of these tests and determinations, in which a constant feed of $\frac{1}{75}$-in. was maintained, are given in Table 7.

These results are exhibited graphically in Fig. 84 (page 871), from an examination of which it will be seen that the cutting capability of a lathe roughing tool, under conditions which embody a constant average cutting speed, a constant life of the tool, and a correspondingly variable depth of cut, does depend somewhat on the area of section of the tool-steel as well as upon the radius of the cutting edge of the tool. It should be observed, however, that the effect of an increase in the sectional dimensions of the tool-steel is more pronounced with a small cutting-edge radius

Fig. 81. RELATION BETWEEN SIDE RAKE ANGLE AND NET HORSE-POWER CONSUMED BY ROUGHING TOOL-MILD STEEL BAR

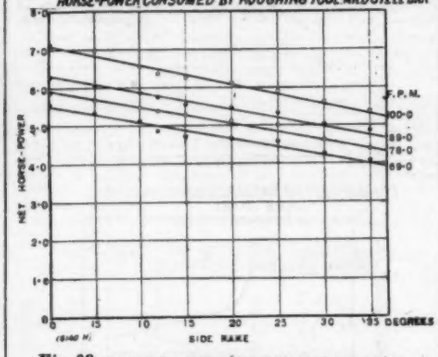


Fig. 82. RELATION BETWEEN SIDE-RAKE ANGLE & NET HORSE-POWER CONSUMED BY ROUGHING TOOL. MEDIUM STEEL BAR.

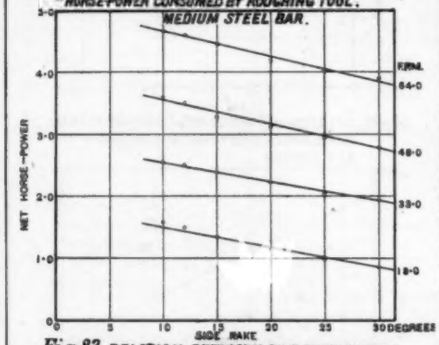
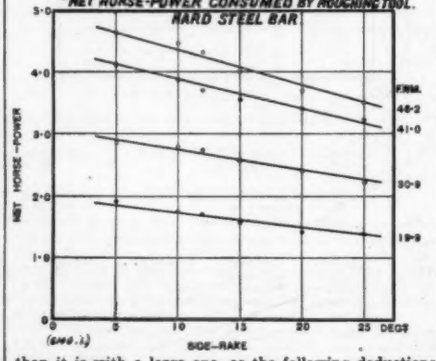


Fig. 83. RELATION BETWEEN SIDE-RAKE ANGLE & NET HORSE-POWER CONSUMED BY ROUGHING TOOL. HARD STEEL BAR.



than it is with a large one, as the following deductions from the above result show :—

Radius of Nose.	Superiority of $1\frac{1}{4}$-in. Square Tool over $\frac{1}{2}$-in. Square Tool.
$\frac{1}{4}$-in.	21 per cent.
$\frac{3}{8}$-in.	17 per cent.
$\frac{1}{2}$-in.	5 per cent.

From these deductions and the character of the curves in the Fig. 84, it is quite conceivable that there is a cutting-edge or nose-radius which is associated with no variation of cutting capability when the section of the tool-steel is either increased or reduced. Generally, however, under the above conditions of cutting speed, life of tool, and depth of cut, the section of the tool-steel, as well as the radius of the cutting edge, is a factor in the cutting power of a lathe roughing tool. At the same time it should be pointed out that there does not appear to be any even comparatively simple relationship between the depth of cut, the area of section of the tool-steel, and the radius of the cutting edge, when a constant average cutting speed and a constant feed are adopted.

As a matter of general interest, it may be pointed out that the dotted curve in Fig. 84 is a curve for the case in which the radius of the cutting edge is proportional to the square root of the sectional area of the tool-steel, the $\frac{1}{4}$-in. square tool being taken as the basic tool. It is thus similar to the curve which is given in Fig. 40 of the original paper.*

In the second series of experiments, in connexion with which the second form of the speed-increment test was adopted, tests were made on the mild-steel and hard-steel test-bars, designated A and C respectively. In the tests on the mild steel bar, the starting speed selected was 90 ft. per minute with a speed-increment of 1 ft. per minute per minute. For each test the depth of the cut was maintained constant at $\frac{4}{75}$-in., and the feed constant at $\frac{1}{75}$-in. per revolution. Tools of three sections were used in the tests, these sections being $\frac{1}{2}$-in. square, $\frac{3}{4}$-in. square, and $1\frac{1}{4}$-in. square. Three cutting-edge radii were adopted, namely, 0, $\frac{1}{4}$-in., and $\frac{1}{2}$-in. the tools which had a cutting-edge radius of 0 being, of course, ground to a sharp point.

Table 7.—*Tool-Section and Nose-Radius Tests on Hard-Steel Bar, C.*

Speed-increment Tests, starting at 20 ft. per minute with $\frac{1}{75}$-in. feed.

Section of Tool-Steel.	Depth of Cut corresponding to Standard Tool-Life of 20 Minutes.		
	Nose-radius = 0 in.	Nose-radius = $\frac{1}{4}$ in.	Nose-radius = $\frac{1}{2}$ in.
in.	in.	in.	in.
$\frac{1}{2} \times \frac{1}{2}$	0·137	0·193	—
$\frac{3}{4} \times \frac{3}{4}$	0·175	0·232	0·296
1×1	0·201	0·265	0·307
$1\frac{1}{4} \times 1\frac{1}{4}$	0·211	0·272	0·311

In these tests each tool was worked until its cutting edge completely broke down, and the volume of material removed from the test-bar by the tool under such conditions was taken to be a criterion of the cutting capabilities of the tool. The durations of the tests representing the different conditions and the average cutting speeds and outputs for the different tools were found to be all different, as is shown in the following Table, wherein are summarized the results of these tests, each of these results being the average of the results of four individual tests.

The starting speed selected for the tests on the hard-steel bar was 30 ft. per minute, the speed-increment was 1 ft. per minute, the depth of cut, which was maintained constant, was $\frac{1}{4}$-in., whilst the feed, which was also maintained constant, was $\frac{1}{75}$-in. per revolution. In these tests, only two cutting-edge radii were made

Table 8.—*Tool-section and Nose-radius Tests on Mild-Steel Bar, A.*

Speed-increment Test with Constant Depth of Cut.

Section of Tool-Steel.	Radius of Nose of Tool = 0	Radius of Nose of Tool = $\frac{1}{4}$ in.	Radius of Nose of Tool = $\frac{1}{2}$ in.
	Average Life of Tool, in Minutes and Seconds.		
$\frac{1}{2}$ in. square	15 30	19 50	23 25
$\frac{3}{4}$ in. square	17 10	22 52	26 40
$1\frac{1}{4}$ in. square	20 52	28 20	31 30
	Average Output of Tool, in Cubic Inches of Metal.		
$\frac{1}{2}$ in square	247	310	373
$\frac{3}{4}$ in. square	267	363	432
$1\frac{1}{4}$ in. square	328	461	521
Superiority of $1\frac{1}{4}$ in. square tool over $\frac{1}{2}$ in. square tool	23 per cent.	27 per cent.	23 per cent.

use of, these being $\frac{1}{2}$-in. and $\frac{1}{4}$-in., it being found that the cutting edge with a sharp angular point did not break down in the same manner as did the cutting edges which were more or less curved, so that it was very difficult to determine the precise point of breakdown of the cutting-edge in such a case. Four tool sections were used in these tests, these ranging from $\frac{1}{2}$-in. square to $1\frac{1}{4}$-in. square, and the general conditions of the tests were the same as in the tests on the mild-steel bar. The results of the tests are tabulated below in Table 9, each result given being the average of the results of four individual tests. Regarding the results of these individual tests it may be stated that the variations amongst them for each particular set of conditions were not very great, the maximum variation observed being of the order of 15 per cent.

A comparison of the results contained in Tables 7, 8, and 9 will show that, when the average cutting and the life of the tool are constant qualities, the superiority of the tool with the larger section is generally greater than when the depth of cut is the constant quantity, it being roughly twice as great in the former case as in the latter. It will be further seen that this superiority due to increased sectional dimensions of the tool falls off considerably in the first case when the radius of the cutting edge is increased, whereas in the latter case this superiority appears to have a fairly constant value.

Regarding the influence of variations in the radius of

* Proceedings, I.Mech.E., 1913, page 1111.

* Proceedings, I.Mech.E., 1913, page 1113.

the cutting edge upon the output or efficiency of a lathe roughing tool it will be seen that this is much more considerable proportionately than the influence of variations of the sectional dimensions of the tool-steel. Thus, with an increase of the radius of the cutting edge from $\frac{1}{8}$ in. to $\frac{1}{4}$ in., the improvement in the cutting

TABLE 9.—*Tool-Section and Nose-Radius Tests on Hard-Steel Bar, C.*

Speed-increment Test with Constant Depth of Cut.

Section of Tool-Steel.	Radius of Nose of Tool = $\frac{1}{8}$ in.	Radius of Nose of Tool = $\frac{1}{4}$ in.
	Average Life of Tool, in Minutes and Seconds.	
$\frac{1}{2}$ in. square	11 12	15 32
$\frac{3}{4}$ in. square	12 8	16 33
1 in. square	12 30	17 13
1$\frac{1}{4}$ in. square	12 58	17 36
	Average Output of Tool, in Cub. In. of Metal.	
$\frac{1}{2}$ in. square	49·3	72·7
$\frac{3}{4}$ in. square	54·3	78·3
1 in. square	56·9	82·7
1$\frac{1}{4}$ in. square	58·8	85·0
Superiority of 1$\frac{1}{4}$ in. square tool over $\frac{1}{2}$ in. square tool	8·3 per cent.	8·6 per cent.

efficiency of the tool varies from 14 per cent. to 48 per cent., according to the general conditions, the higher values of this improvement being associated with the tools having the smaller sections.

6.—Influence of Height of Cutting Edge upon Cutting Efficiency of Turning Tools.

The question of the position of the cutting edge of a lathe turning tool with respect to the centre of the work-piece or test-bar upon which the tool is working, is one of the several questions which enter into the larger problem of general turning-tool efficiency. Concerning this point, however, there does not appear to be a consensus of opinion amongst those to whom the question is of importance. In many quarters it is the practice to arrange the cutting edge or point of a lathe-turning tool above the horizontal plane which passes through the axis of rotation of the work-piece; in other instances, the cutting edge or point of the tool is disposed in this plane; whilst in some few cases, it actually falls below this plane.

In the majority of cases wherein the practice of placing the cutting edge or point of the tool above the central horizontal plane is adopted, it is apparently for the assumed reason that the strength of the nose of the tool to resist fracture is thereby increased, the question as to whether this, incidentally or otherwise, affects the cutting power of the tool not being taken into account at all.

To determine this latter point, that is, whether the cutting power of a lathe turning tool is influenced by the position of its cutting edge or point with respect to the axis of rotation of the work-piece, several series of experiments which are described below were undertaken.

In the first series of experiments, all the tools, which were made of ordinary non-vanadium high-speed steel, were ground and hardened exactly alike, the shape of nose selected being the standard shape already described under Section I, whilst the angles ground on the tools were as follows:—

Top rake, front = 11 deg. Front of heel clearance = 5 deg.

Top rake, side = 23 deg. Side clearance = 4 deg.

The tools were $\frac{3}{4}$ in. by $\frac{1}{2}$ in. in section, and the test-bar on which the experiments were made was the mild-steel bar, A. The test adopted was of the constant-speed type, the involved variable being the duration of the test or the life of the tool. The cutting speed selected was 147 ft. per minute, with a depth of cut of $\frac{1}{8}$ in. and a feed of $\frac{1}{16}$ in. per revolution. Three positions of the cutting edges of the tools were experimented with, these being as follows:—

1. $\frac{1}{8}$ in. above the central horizontal plane (A, Fig. 85).
2. In this plane (B, Fig. 85).
3. $\frac{1}{8}$ in. below this plane (C, Fig. 85).

The mean diameter of the test-bar was 10·062 in., so that the angle (θ, Fig. 85) between the line joining the centre of the bar and the cutting point of the tool in each of the first and third positions and the central horizontal plane (represented by the line XY in the figure) was about 4$\frac{1}{2}$ deg. The three operative front clearance angles were, therefore, $\frac{1}{2}$ deg., 5 deg., and 9$\frac{1}{2}$ deg. respectively, and the corresponding operative front rake angles were 15$\frac{1}{2}$ deg., 11 deg., and 6$\frac{1}{2}$ deg. respectively.

The results of these tests are given in Table 10, each of these results being the average for four individual tests.

In each case the net power consumed at the nose of the tool is the difference between the power consumed with the cut in and that consumed with the cut out, the general conditions being otherwise the same in the two cases.

These results indicate that, with a constant tool angle, there is a slight gain to be secured by raising the cutting edge of the tool slightly above the lathe centres or the axis of rotation of the work-piece, both from the point of view of the durability of the cutting edge of the tool and that of the net power-consumption. In these tests, the actual improvement in the durability and

TABLE 10.—*Cutting-edge Height Tests on Mild-Steel Test Bar, A.*

Variable Operative Clearance and Rake Angles.

Position of Cutting Edge of Tool.	Average Cutting Speed.	Area of Cut Depth × Feed.	Average Life of Tool.	Average Volume of Metal Removed by Tool.	Average net Power Consumed at Nose of Tool.
	ft. per min.	in.	min. sec.	cub. in.	
$\frac{1}{8}$ in. above centres	147	$\frac{1}{8} \times \frac{1}{16}$	8 11	150·4	9·24 h.p.
On centres ..	147	$\frac{1}{8} \times \frac{1}{16}$	7 54	145·2	9·51 h.p.
$\frac{1}{8}$ in. below centres	147	$\frac{1}{8} \times \frac{1}{16}$	4 17	99·1	9·75 h.p.

cutting efficiency of the tool was about 3·5 per cent., and the reduction in the net amount of power consumed by the tool was about 3 per cent., two amounts which are quite comparable.

On the other hand, the above results show that, when the cutting edge of the tool is placed below the centres of the lathe, a depreciation in the durability and cuttings

Fig. 84. EFFECT ON OUTPUT OF CROSS SECTIONAL AREA OF TOOL-STEEL AND NOSE-RADIUS OF TOOL.

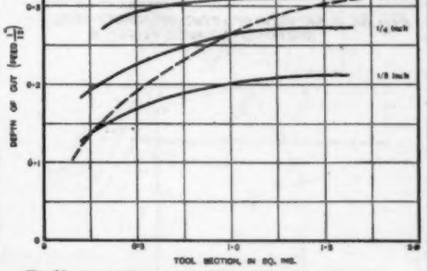
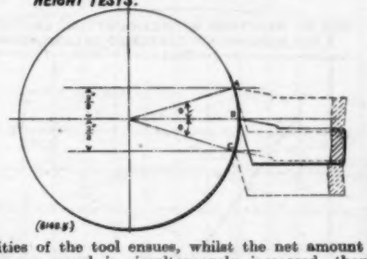


Fig. 85. RELATIVE POSITIONS OF LATHE TOOLS IN HEIGHT TESTS.



qualities of the tool ensues, whilst the net amount of power consumed is simultaneously increased, though not proportionately.

The above net power-consumption phenomena may be due to the differences in the operative angles of top rake, the tools which were disposed with their cutting edges above the lathe centres having the largest operative rake angles and, therefore, cutting more freely than the others. This case is not, however, quite identical with that wherein tools with different angles of rake ground on them are all placed with their cutting edges in the central horizontal plane, since in this latter case the tool angles of such tools would vary and the cross-sectional areas of their noses, one of the factors in the conduction of heat away from the cutting edges, would also all be different, whilst the operative clearance angles would all be equal.

In the second set of experiments, those tools whose cutting edges were to be placed above the lathe centres, had an enhanced amount of clearance *ground* on them to allow for the curvature of the test-bar, and thus to make the operative clearance angle equal to that of the tools disposed normally with respect to the bar. For the same reason, those tools which were to have their cutting edges placed below the lathe centres had a reduced amount of clearance *ground* on them. One of the conditions of these tests was, therefore, the maintenance of a constant operative clearance angle. The tools were all ground alike on the lip or upper surface, so that the tool angle was a variable quantity, since its value depended upon the amount of clearance ground on the tool in each case.

These tests were made on the hard-steel test bar, C, with tools of the ordinary high-speed quality 1$\frac{1}{4}$ in. square in section. Each tool was ground with 6 deg. of front top rake and 12 deg. of side rake, whilst the clearance angles ground on the tools were as follows:—

Disposition of Cutting Edge of Tool.	Clearance Angle Ground on Tool.
1. Above the lathe centres.	10 deg.
2. On the lathe centres.	5 deg.
3. Below the lathe centres.	0 deg.

Hence, since the vertical distances between the lathe centres and the cutting edges of the tools in positions 1 and 3 were $\frac{5}{16}$ in. throughout, and the mean diameter of the test-bar was 8 in., the operative angle of clearance in each case was about 5 deg.

The type of test adopted in this case was the constant-speed test, the duration of the test, or the life of the tool, being taken as the criterion value in regard to the cutting capabilities of the tool. The cutting speed selected was 42 ft. per minute, with an area of cut of $\frac{1}{8}$ in. deep by $\frac{1}{16}$ in. feed throughout, this area of cut being maintained as constant as possible.

The average results of these tests are given in Table 11 (below), each result given therein being the average of the results of four individual tests distributed as evenly as possible over the length of the test-bar, so as to average out the effects of any possible variations in the texture of the test-bar.

These results show that with a constant operative clearance angle a slight loss in durability follows the raising of the cutting edge of the tool above the lathe centres, the loss in this case being about 6 per cent. On the other hand, the net power consumption shows a reduction when the cutting edge is raised, the gain in this direction being of the order of 7 per cent., and due to the reduction in the operative rake angles.

In connection with the position of the cutting edge of the tool below the lathe centres, it will be seen that the durability is considerably less than when the tool is in its normal position, whilst the net power consumption is a little greater, a result which is identical with that obtained in the first series of tests.

Other sets of tests were made with tools of large and small section, and with various shapes of nose, on both the mild- and hard-steel bars, but in every case results similar to the above were obtained.

TABLE 11.—*Cutting-edge Height Tests on Hard-Steel Test Bar, C.*

Constant Operative Clearance and Variable Top Rake Angles.

Position of Cutting Edge of Tool.	Average Cutting Speed.	Area of Cut. Depth × Feed.	Average Life of Tool.	Average volume of Metal Removed by Tool.	Average net Power Consumed at Nose of Tool.
	ft. per min.	in.	min. sec.	cub. in.	
$\frac{1}{16}$ in. above centres	42	$\frac{1}{8} \times \frac{1}{16}$	7 6	74·6	6·44 h.p.
On centres	42	$\frac{1}{8} \times \frac{1}{16}$	7 32	79·1	6·93 h.p.
$\frac{1}{16}$ in. below centres	42	$\frac{1}{8} \times \frac{1}{16}$	3 50	40·2	7·13 h.p.

7.—Influence of Forging Operation on Cutting Power of Lathe Roughing Tool.

The shape of nose of the tool which was adopted as the standard in the original investigations is such that it can be obtained from the plain bar by the single process of grinding, but in the case of the majority of shapes of nose it is necessary to have the nose shaped initially by forging or smithing and finished by grinding. It appeared desirable, therefore, to determine whether this initial forging operation had any influence—deleterious or otherwise—on the cutting qualities of lathe turning tools.

In this determination, tests were made on the mild- and hard-steel test-bars, A and C respectively, with both plain carbon and ordinary high-speed steel tools, the forged tools being finish-ground and hardened exactly like the unforged ones. The speed-increment form of test was applied, the average speed-increment being 1 ft. per minute throughout the whole series of tests. The starting speeds, areas of cut, and other data are given in Tables XII and XIII, page 872, in which the results of the tests are also given, these being in the form of averages. The shape of tool nose selected was the standard one already described, the side and front rake angles being 12 deg. and 6 deg. respectively for the tools on the hard bar, and 23 deg. and 11 deg. respectively for the tools on the mild bar, with a uniform clearance angle of 5 deg.

These results demonstrate that there is no appreciable difference between the cutting power of a forged turning tool and that of a similar unforged one, provided that both tools are made of the same kind of steel and pass through the same hardening process.

This conclusion has been confirmed by results obtained incidentally from an extensive investigation which was made on tool-steels as a special war research in the University of Sheffield. In this investigation nearly 1000 individual tests were made on 332 tools of similar shapes under identical conditions, one-half of this number having forged noses, and the other half unforged ones. An analysis of the results of the investigation shows that the two kinds were fairly evenly divided, practically one-half of the tools of each kind giving results above the mean, and the other half below, with an average superiority of not quite 0·25 per cent. in favour of the forged tools.

8.—Influence of Direction of Cutting Edge on Net Power Consumption involved in Turning Steel.

In the previous paper it was shown that the results of actual experiments indicated that the life of durability of a lathe turning tool was dependent to some extent upon the length of the part of the cutting edge in action. That is, the shape and disposition of the cutting edge are amongst the factors which influence the life

TABLE 12.—Forging Tests on Plain Carbon Steel Tools.

Dimensions and Description of Tool.	Description of Test Bar.	Starting Speed of Test.	Area of Cut. Depth × Feed.	Average Life of Tool.	Average Volume of Metal Removed.	Superiority (Based on Volume of Metal Removed).
		ft. per min.		min. sec.	cub. in.	
½ in. sq. forged	Hard steel (C)	10	⅛ in. × 1/32 in.	7 40	5·17	
½ in. sq. unforged ..		10	⅛ in. × 1/16 in.	7 47	5·31	2·7 per cent.
1 in. sq. forged		10	¼ in. × 1/16 in.	6 35	8·61	
1 in. sq. unforged ..		10	¼ in. × 1/8 in.	6 43	8·85	2·8 per cent.
½ in. sq. forged	Mild steel (A)	20	⅛ in. × 1/32 in.	17 8	24·4	
½ in. sq. unforged ..		20	⅛ in. × 1/16 in.	17 29	25·0	2·5 per cent.
1 in. sq. forged		20	¼ in. × 1/16 in.	14 25	39·5	
1 in. sq. unforged ..		20	¼ in. × 1/8 in.	15 7	41·5	5·0 per cent.
½ in. sq. forged	Mild steel (A)	20	⅛ in. × 1/32 in.	11 21	21·7	
½ in. sq. unforged ..		20	⅛ in. × 1/16 in.	11 49	22·5	3·7 per cent.
1 in. sq. forged		20	¼ in. × 1/16 in.	7 5	24·7	
1 in. sq. unforged ..		20	¼ in. × 1/8 in.	7 9	24·9	0·8 per cent.

TABLE 13.—Forging Tests on Ordinary High-Speed Steel Tools.

Dimensions and Description of Tool.	Description of Test Bar.	Starting Speed.	Area of Cut. Depth × Feed.	Average Life of Tool.	Average Volume of Metal Removed.	Superiority (Based on Volume of Metal Removed).
		ft. per min.		min. sec.	cub. in.	
½ in. × ½ in. forged ..	Hard Steel (C)	60	⅛ in. × 1/16 in.	6 16	19·8	1·5 per cent.
½ in. × ½ in. unforged ..		60	⅛ in. × 1/8 in.	6 1	19·5	
1½ in. sq. forged		40	⅛ in. × 1/16 in.	9 48	98·9	0 per cent.
1½ in. sq. unforged ..		40	⅛ in. × 1/8 in.	9 48	98·9	
½ in. × ½ in. forged ..	Mild Steel (A)	100	1/16 in. × 1/16 in.	9 13	182	
½ in. × ½ in. unforged ..		100	1/16 in. × 1/8 in.	9 16	183	0·5 per cent.
1½ in. sq. forged		90	⅛ in. × 1/16 in.	10 13	369	
1½ in. sq. unforged ..		90	⅛ in. × 1/8 in.	10 26	374	1·4 per cent.

of a turning tool, the experimental results demonstrating the fact that, by bringing the cutting edge of a tool more nearly parallel to the axis of the test-bar or work-piece and so, for any given depth of cut, increasing the length of the active part of the cutting edge, the life of the tool is increased.

To amplify these results, further lathe tests have been made with a view to the determination of the influence of the direction and active length of the cutting edge of a tool upon the net power consumed in turning steel.

For the purposes of these tests, twelve high-speed tools, each of a section 1¼-in. square, were prepared. These were divided into six sets, of two tools each, the tools of each set having a plan shape of nose peculiar to that set. The general plan shape of the tool-noses is given in Fig. 86, the cutting edge *ab* being arranged in the various sets of tools at the angles given in Table 14, below, and terminating in a curve of ¼-in. radius. In this Table are also given the rake angles in the vertical planes represented by the lines AB and XY of the figure, the side rake being kept as nearly equal to 10 deg. as possible, compatible with the cutting *ab* being horizontal.

The tests were made on the hard-steel test-bar C, a constant average cutting speed of 26 ft. per minute being maintained throughout each test with a depth of cut of ⅛-in. and a feed of 1/16-in. per revolution. The results of the tests are set forth in Table 15.

These results are represented diagrammatically in Fig. 87, in which figure the net horse-power consumed is plotted against the angle θ (the general inclination of the cutting edge to the axis of the test-bar or work-piece).

TABLE 14.—*Angles of Lathe Turning Tools.*

No. of Set.	Angle θ (Fig. 86.)	Angle Φ (Fig. 86.)	Angle in Plane AB (Front Rake.)	Angle in Plane XY (Side Rake.)	Clearance.
	deg.	deg.	deg.	deg.	deg.
1	90	15	0	10	5
2	80	15	1	10	5
3	65	15	4	10	5
4	45	15	10	10	5
5	30	15	10	9	5
6	15	15	10	4	5

TABLE 15.—*Net Power Consumption of Tools Described in Table 14.*

No. of Set.	Net Horse-power consumed in Tests.
1	4·84
2	4·83
3	4·84
4	5·08
5	5·22
6	5·39

This figure indicates that there is practically no variation in the net power consumption for all values of the mean axial angle of the cutting edge (θ) between 90 deg. and 65 deg. under the condition of nose-radius and depth of cut adopted in these tests. The explanation of this is that, under these conditions, the length of the active part of the cutting edge is practically a constant quantity for all values of θ between 90 deg. and 65 deg. inclusive. This latter value of θ, however, appears to be a critical one for these conditions, since, with a reduction of the value of θ from this point, there is a general and comparatively constant increase in the net power consumption.

Combining this result with the durability-test result, it would appear that an increase in the durability of a tool by reducing the mean axial cutting-edge angle below 65 deg. can only be secured at the expense of the net power consumption. It is not, however, suggested that 65 deg. is necessarily the critical value of this angle in

Fig. 86. PLAN-VIEW OF LATHE ROUGHING TOOL SHOWING VARIABLE ANGLE, θ.

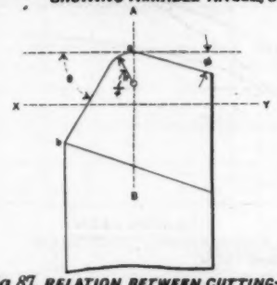
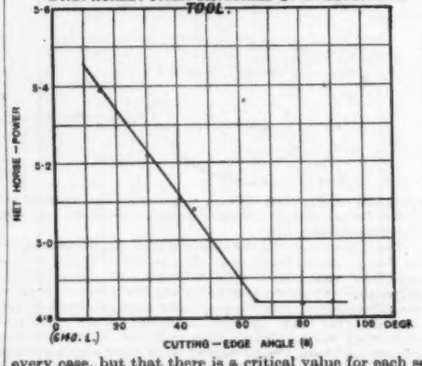


Fig. 87. RELATION BETWEEN CUTTING-EDGE ANGLE(θ) & NET HORSE-POWER CONSUMED BY LATHE ROUGHING TOOL.



every case, but that there is a critical value for each set of conditions of nose-radius and depth of cut which is peculiar to such conditions.

Some points of interest may be observed in the data arranged in Table 16, these data having reference to some of the characteristics of the actual turnings removed by the above sets of tools.

TABLE 16.—*Data Relating to Turnings from Hard-steel Test-Bar.*

No. of Set of Tools.	Approximate Width of Turnings.	Approximate Mean Thickness of Turnings.	Approximate Mean Diameter of Coils of Turnings.
	in.	in.	in.
1	⅛	1/32	4
2	⅛	1/16	4
3	⅛	1/32	4
4	1/16	1/16	3
5	1/16	1/32	2
6	1	1/16	1

These data show that there is very little difference between the turnings removed by tools whose cutting edges are disposed at angles between 65 deg. and 90 deg. to the axis of the test-bar or work-piece, as would, of course, be expected from tools the active lengths of whose cutting edges are practically equal. On the other hand, there are great differences between the turnings removed by tools with cutting edges arranged at angles below 65 deg. to the axis of the test-bar or work-piece. A comparison of Tables 15 and 16 will show that, whilst there is some connection between the net power consumption and the general proportions of the turnings actually removed by turning tools working under conditions similar to the above, the variations of the former are not comparable with the latter.

9.—Influence of Cutting Speed on Net Energy per Cubic Inch of Metal Removed by Lathe Roughing Tool.

Experiments to determine the influence, if any, of the cutting speed upon the net amount of energy consumed in the removal of a cubic inch of metal from a steel test-bar or work-piece by a lathe roughing tool have also been conducted. These experiments were made with ordinary high-speed steel tools, 1¼-in. square in section, on both the aforementioned mild and hard-steel bars, A and C respectively. The standard shape of tool-nose of the original tests was adopted, the tools which were tested on the soft bar having a front rake of 11 deg. and a side rake of 23 deg., whilst the corresponding angles ground on the tools which were tested on the hard bar were 4½ deg. and 10 deg. respectively. In each case the clearance angles were 5 deg., and the cutting edges of all the tools were arranged in the horizontal plane which contained the common axis of the lathe centres.

Two sets of tests were made on each bar, each set with a different area of cut and embracing six or seven individual tests at different speeds. In the case of the tests on the soft bar, it was found possible to work through a cutting-speed range from 10 to 120 ft. per minute; whereas in the case of the tests on the hard bar, it was not found practicable to go beyond a cutting speed of about 60 ft. per minute on account of the short life of the tools at speeds above this limit. The net power required in each test was determined by taking the difference between the total amount of power required with the tool actually cutting and that required with the tool out of action but moving with the slide-rest at the speed of the test feed. The volume of metal removed per hour was calculated from the data of the test in each case. The results of the tests are presented in Tables 17.

These results indicate that the specific net energy consumption is influenced only very slightly, if at all, by the magnitude of, or changes in, the cutting speed, and still less slightly by the magnitude of, or changes in, the area of cut. As a corollary, therefore, it follows that the specific forces which accompany cutting do not depend to any marked extent upon the cutting speed or the area of cut. In any case, the tendency of influence is opposite in character to the change in either cutting speed or area of cut. This conclusion is borne out by the test-results tabulated in the original paper.

TABLE 17.—*Energy per cubic inch of Metal removed by Turning Tool.*

Area of Cut.	Average Cutting Speed.	Cubic Inches removed per hour.	Net Power Consumed.	Cubic Inches per net h.p.-hour.	Net h.p.-hour per cubic inch.
(*a*) Tests made on Mild-steel Bar with High-speed Tools.					
⅛ × ⅛	10·1	227	2·05	110·9	0·0090
,,	21·0	472	4·09	115·4	0·0087
,,	32·0	720	6·13	117·4	0·0085
,,	43·5	990	8·48	116·8	118·0 0·0086 0·0085
,,	62·1	1,399	11·40	122·6	0·0082
,,	79·0	1,778	14·74	120·6	0·0083
,,	106·1	2,387	19·50	122·4	0·0082
⅛ × 1/16	10·1	152	1·35	112·2	0·0089
,,	20·5	308	2·69	114·3	0·0088
,,	33·5	503	4·35	115·6	0·0087
,,	50·1	751	6·27	119·6	117·3 0·0084 0·0085
,,	69·5	1,043	8·74	119·3	0·0084
,,	92·2	1,373	11·41	121·5	0·0082
,,	118·5	1,778	15·00	118·5	0·0084
(*b*) Tests made on Hard-steel Bar with High-speed Tools.					
⅛ × 1/16	6·8	102	1·23	82·5	0·0121
,,	10·0	150	1·85	81·1	0·0123
,,	18·1	271	3·35	81·2	82·0 0·0123 0·0122
,,	27·0	405	4·90	82·8	0·0120
,,	38·5	578	7·06	81·7	0·0122
,,	53·0	795	9·58	83·0	0·0120
⅛ × 1/32	7·1	64	0·78	81·9	0·0122
,,	10·7	96	1·18	81·6	0·0122
,,	18·2	164	2·02	81·1	0·0123
,,	31·5	284	3·52	80·5	81·5 0·0124 0·0122
,,	40·5	365	4·30	80·7	0·0124
,,	48·5	441	5·38	82·0	0·0122
,,	58·0	522	6·29	83·0	0·0120

10.—Cooling and Lubrication Tests.

In all the tests, except the finishing tests, which have so far been described, no cooling or lubricating medium of any kind was employed, each tool being tested "dry." Tests have, however, been made with the object of determining the quantitative effect of a stream of liquid having cooling and lubricating properties on the cutting qualities of a lathe rough-turning tool.

These tests were made with twelve 1¼-in. square ordinary high-speed steel tools, all ground alike to the standard shape with a cutting-edge radius of 1/32-in., and all hardened alike. The tool angles were as follows:—

Top rake—front = 11 deg. Front clearance = 5 deg.
Top rake—side = 23 deg. Side clearance = 5 deg.

The test-bar selected for these experiments was the mild-steel bar, A, already described. On this bar the cut was ⅛ in. deep, with a feed of 1/16 in. per revolution of the bar. The test applied was the ordinary speed-increment test, the starting speed being 50 ft. per minute, and the speed-increment 1 ft. per minute per minute.

Two sets of experiments were made. In the first set,

a soluble-oil compound diluted with water in the ratio of 3 to 1 was used as the lubricant-coolant; in the second set, compressed air was used as the coolant, both with and without the diluted soluble-oil compound.

In the first set of tests a nozzle $\frac{5}{16}$ in. in diameter was used to direct the stream of coolant on to the turning or chip at the point at which it left the bar, as shown at A in Fig. 88 (below). This is, generally, the direction of a stream of coolant which is the most easily attainable. The water was put into motion by means of an electrically driven geared pump, the speed of which was varied to give different stream flows or velocities. At each stream flow or velocity, which was actually measured, three separate tests were made, the average results of which are given in Table 18. From this Table it will be observed that the greatest flow used in the tests was equal to about 1 gallon of water being projected on the turning per minute.

The results in Table 18 indicate that the gain to be derived from the use of a stream of coolant on a lathe turning tool working on steel is not a constant quantity, but rises simultaneously with the flow of the coolant when the velocity of discharge of the latter bears a constant ratio to the rate of discharge. The results of other tests, however, appear to show that there is a limiting rate of flow of coolant in every case, and that beyond this rate of flow no increase of gain in the cutting speed or capabilities of the tool can be secured, but that rather there is an actual falling off of the gain secured at the limiting rate of flow. In the above case, the limiting rate is probably in the neighbourhood of the rate corresponding to the maximum flow used.

The results of other tests demonstrate that, if the same flow is used in conjunction with a smaller area of cut, or a stream of proportionately larger section with the same velocity is used in conjunction with the same area of cut, the improvement in the cutting capabilities of the tool is, within limits, increased.

TABLE 18.—*Effect of Coolant on Cutting Qualities of High-speed Lathe Tools.*

Direction of Flow of Coolant: A (Fig. 88) on Turning.
Starting Speed = 50 ft. per min.
Area of Cut = $\frac{1}{4}$ in. deep × $\frac{1}{16}$ in. feed.

Flow of Coolant.		Average Life Tool.	Average Break-down Speed.	Average Volume of Metal Removed.	Improvement in Cutting Qualities of Tools.
cub. ft. per min.	gallons per hour	min. sec.	ft. per min.	cub. in.	per cent.
0	0	13 41	63·3	194·0	0
0·0245	9·17	16 19	66·0	236·7	22
0·0648	24·24	17 7	66·3	249·6	29
0·1053	39·40	17 45	67·3	260·5	34
0·1532	57·32	18 8	68·0	267·5	38

Average percentage improvement in the cutting qualities of the tools due to the influence of the coolant at various flow = 31 per cent.

In Table 19 (below) are given the results of tests made with a view to the determination of the effect of a reduction in the area of cut upon the improvement in the cutting power of a high-speed lathe tool registered as the result of the use of a stream of coolant. In these tests, the comparative speed-increment test was applied as above, the starting speed being 20 ft. per minute, and the increment of speed 1 ft. per minute applied every minute. The tools experimented with were made from $\frac{3}{4}$ in. by $\frac{1}{2}$ in. bars, and ground to the standard shape with angles suitable for use on the hard-steel bar, C, on which these tests were made. The area of cut adopted was $\frac{1}{4}$ in. deep by $\frac{1}{16}$ in. traverse, this being found to give a tool life ranging from 15 minutes to 23 minutes. This area of cut is just one-half of that adopted in the previous tests, the reduction being obtained by halving the depth of cut.

TABLE 19.—*Effect of Area of Cut on Improvement in Cutting Power High-speed Lathe Tools due to use of Coolant.*

Direction of Flow of Coolant: A (Fig. 88) on Turning.
Starting Speed = 20 ft. per min.
Area of Cut $\frac{1}{8}$ in. deep × $\frac{1}{16}$ in. feed.

Flow of Coolant.		Average Life of Tool.	Average Break-down Speed.	Average Volume of Metal Removed.	Improvement in Cutting Qualities of Tools.
cub. ft. per min.	gallons per hour	min. sec.	ft. per min.	cub. in.	per cent.
0	0	15 3	34·5	51·3	0
0·0245	9·17	18 45	38·5	69·1	35
0·0648	24·24	22 10	42·0	85·7	67
0·1053	39·40	22 52	42·3	89·1	74
0·1532	57·32	22 11	41·3	85·5	67

Average percentage improvement in the cutting qualities of the tools due to the influence of the coolant at various flows = 61 per cent.

A comparison of this and the immediately preceding Table, as well as the curves given in Fig. 89, and based upon these Tables, will show that the percentage improvement in the cutting power of the tools is greater for each flow with the smaller area of cut, the ratio of the average percentage improvements in cutting power for the two areas of cut being practically 2 to 1 in favour of the smaller area of cut. This ratio, it is to be noted, is approximately equal to the reciprocal ratio of the active lengths of cutting edge in the two cases, and that it is quite probable that a reduction in the feed instead of a reduction in the depth of cut would not have resulted in such a large increase in the gain of cutting power.

It is, further, quite reasonable to assume that there is a limiting area of cut for each section of stream, and that no increase in the gain of cutting power can be registered as the result of any further reduction in the area of cut below this value.

The phenomenon of the limiting flow of coolant under conditions which are otherwise constant is observable in connection with Table 19, and the upper curve in Fig. 89. The explanation of this phenomenon is probably to be found in the fact that at practically all stream velocities there is a perceptible amount of splashing, and that as the velocity is increased the amount of splashing is also increased, not necessarily in direct proportion to the velocity-increase, but, as is more probable, to the square of the velocity-increase. Beyond a certain velocity (the velocity corresponding to the limiting or critical rate of flow for the particular conditions obtaining in any case) the loss due to the increased splashing is greater than the gain due to the increased flow, and the increase in the velocity of the useful part of the stream, with the result that the net heat-extracting power of the stream is actually reduced, this producing a reduction in the cutting power and durability of the tool.

Fig. 88. DIAGRAM SHOWING DIRECTION OF FLOW OF COOLING MEDIA ON LATHE TURNING TOOL & TURNING.

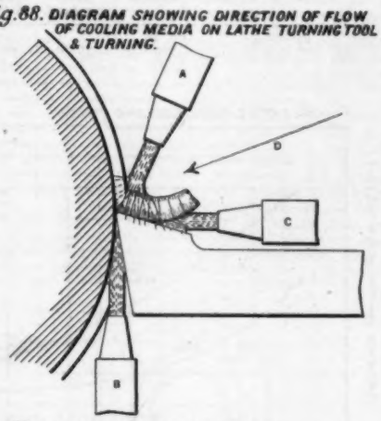
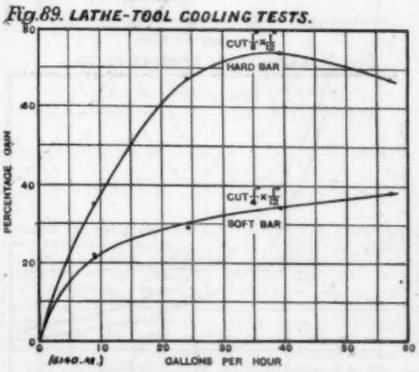


Fig. 89. LATHE-TOOL COOLING TESTS.



Regarding the question of the magnitude of the critical or limiting velocity or rate of flow of the stream or coolant, it should be observed that this does not appear to be a constant quantity for all cases, but that it probably depends upon the section of the stream and its relation to the area of cut. This will be seen from a comparison of Tables 18 and 19, and of the curves given in Fig. 89. In one case, the limiting rate of flow has, apparently, not been quite reached; in the other, its magnitude is clearly indicated at 0·1053 cu. ft. per minute (39·40 galls. per hour), corresponding in this particular case to a stream velocity of 3·30 ft. per second.

An interesting deduction from Tables 18 and 19 is shown in Table 20 (in the next column). It is in regard to the relations between the rate of flow of the coolant, and (1) the specific percentage improvement in cutting power (that is, the percentage improvement in cutting power per gallon per hour) and (2) the specific percentage cutting power (that is, the percentage cutting power per gallon of coolant per hour, with the "dry" or "uncooled and unlubricated" cutting power taken as the standard and represented as 100).

This Table shows, as do the curves given in Figs. 90 and 91, that each of these two specific percentages falls as the rate and velocity of flow of the coolant are increased. It will also be observed that the specific percentage cutting powers for each flow of coolant with the two areas of cut on different test-bars are not very different, this suggesting that the specific percentage cutting power of a tool when working with a coolant does not depend to any material extent upon the relation between the section of the stream of coolant and the area of cut.

A number of tests were made with the object of determining the effect of a variation in the velocity of the flow whilst the rate of flow is kept constant. A variation in the velocity under such conditions is, of course, only possible by varying the cross-sectional area of the stream. This was actually done by substituting a nozzle $\frac{1}{4}$-in. in diameter for the $\frac{5}{16}$-in. nozzle as used in the first tests. Other conditions, however, were identical with those of the tests of Table 18, a rate of flow 0·1532 cu. ft. per minute (57·32 galls. per hour) being adopted for the purposes of comparison. With this rate of flow, an improvement in cutting power of 37·5 per cent. was registered against the 38 per cent. of Table 18, obtained under identical conditions apart from the velocity of flow and the cross-section of the stream. This would seem to show that there is no material gain in cutting power to be secured by the use of a heavy stream at a low velocity as against a lighter stream at a higher velocity, other things being equal, provided that absurdly heavy or light stream-flows are not employed. On the other hand, there is less splashing and throwing of water when the stream is large and the velocity low than when the stream is fine and the velocity high.

TABLE 20.—*Specific Percentage Improvement in Cutting Power due to use of Coolant on Turning Tools.*

Deduced from Data given in Tables 18 and 19.

Coolant Data.		Gain per cent. per gallon per hour.		Cutting Power per cent. per gallon per hour.	
Flow in Gallons per hour.	Velocity of Stream in ft. per sec.	Cut, $\frac{1}{4} \times \frac{1}{16}$ in. on Mild Steel.	Cut, $\frac{1}{4} \times \frac{1}{16}$ in. on Hard Steel.	Cut, $\frac{1}{4} \times \frac{1}{16}$ in. on Mild Steel.	Cut, $\frac{1}{4} \times \frac{1}{16}$ in on Hard Steel.
0	0	0	0	—	—
9·17	0·77	2·41	3·82	13·4	14·8
24·24	2·03	1·20	2·77	5·3	6·9
39·40	3·30	0·87	1·88	3·4	4·4
57·32	4·80	0·66	1·17	2·4	2·9

The results of these tests are also useful for the purpose of showing the effect of an increase of stream-flow with a constant velocity of flow. Thus, taking the rate of flow through the $\frac{1}{4}$-in. nozzle at 0·1532 cu. ft. per minute (57·32 galls. per hour), we find that the rate of flow through the $\frac{5}{16}$-in. nozzle at the same velocity would be $\frac{0 \cdot 1532}{4}$ or 0·0383 cu. ft. per minute (14·33 galls. per hour); and from the lower curve of Fig. 89 we find that the percentage improvement in cutting power which would be obtained, under the conditions of the tests of Table 18, is 24·5 per cent., which compares with the 37·5 per cent. obtained with the four-fold rate of flow. That is to say, by increasing the rate of flow and cross-section of the stream each by 300 per cent., the gain in actual cutting power is increased by only 50 per cent.

Further experiments have been made to determine whether any one direction of the stream of coolant with respect to the cutting edge of the tool is superior to all the others. For this purpose, the conditions of the first tests were repeated with the one exception of the direction of the flow. This latter was changed first to that shown at B in Fig. 88, and then to that shown at C. In the first of these two cases, the nozzle was pointed upwards between the flank of the tool-nose and the test-bar so that the stream of coolant was projected into the angle formed between them. In the second case, the position of the nozzle was such that the stream of coolant was projected between the turning formed from the test-bar and the lip surface of the tool-nose with the object of forcing it as near to the cutting edge as possible.

Tests with two different flows of coolant with direction B were made, the results of these being given in Table 21 (below).

If comparison be made between this Table and Table 18, it will be seen that with this direction of flow there is a gain of 49 per cent. as against one of 29 per cent. for the more usual direction of flow, and also one of 70 per cent. as against one of 34 per cent. These results indicate that this direction of flow is the more efficient of the two; but this is only the case provided that the velocity of flow of the coolant is such that the stream reaches the cutting edge quite readily. When this condition is not satisfied, the gain in cutting power is only very slight.

TABLE 21.—*Effect of Direction of Flow on Gain secured by use of Coolant.*

Direction of Flow of Coolant: B (Fig. 88) between Tool and Test Bar.
Starting Speed = 50 ft. per minute. Area of Cut = $\frac{1}{4}$ in. deep × $\frac{1}{16}$ in. feed.

Flow of Coolant.		Average Life of Tool.	Average Break-down Speed.	Average Volume of Metal Removed.	Improvement in Cutting Qualities of Tools.
cu. ft. per min.	gallons per hour	min. sec.	ft. per min.	cub. in.	per cent.
0·0648	24·24	19 28	69·0	289·7	49
0·1053	39·40	21 45	71·3	329·7	70

Tests were made with only one rate of flow of coolant with the direction C; the results of these are given in Table 22, page 874.

A comparison between this Table and Table 18 will show that the use of a stream of coolant with this direction of flow produces results which are inferior to those obtained with the ordinary direction of flow on the turning, this percentage gain in cutting power of 32

per cent. being comparable with the 38 per cent. gain of Table 18.

Experiments have also been made with a combination of two streams of coolant, the two flows A and B of Fig. 88 forming the combination. In the actual tests the rate of flow in the direction A was 0·1053 cu. ft. per minute (39·40 gallons per hour), whilst that in the other direction was 0·0648 cu. ft. per minute (24·24 gallon per hour), making a total rate of flow of 0·1701 cu. ft. per minute (63·64 gallons per hour). The above test conditions were the same as those which obtained in the

TABLE 22.—*Effect of Direction of Flow on Gain secured by use of Coolant.*

Direction of Flow of Coolant: C (Fig. 88) between Tool and Turning.

Starting Speed = 50 ft. per minute. Area of Cut = ¼ in. deep × $\frac{1}{16}$ in. feed.

Flow of Coolant.		Average Life of Tools.	Average Breakdown Speed.	Average Volume of Metal Removed.	Improvement in Cutting Qualities of Tools.
cub. ft. per min.	gallons per hour	min. sec.	ft. per min.	cub. in.	per cent.
0·1532	57·32	17 31	67·0	256·4	32

first set of coolant tests. The average results of the tests are given in Table 23, from which it will be seen that the cutting qualities of the tools under these conditions were the greatest recorded. Furthermore, it will be observed that the improvement in cutting power due to this combination of flows is practically equal to the sum of the individual improvements which are registered when the two flows are made use of separately. Thus, the sum of these two improvements (as taken from the Tables) equals 34 + 49), that is, 83 per cent., a result which compares with the 87 per cent. gain which is registered in this case.

TABLE 23.—*Effect of Compound Flow of Coolant on Cutting Power of Lathe Tool.*

Directions of Flow: A and B (Fig. 88).

Starting Speed = 50 ft. per minute. Area of Cut = ¼ in. deep × $\frac{1}{16}$ in. feed.

Total Flow of Coolant.		Average Life of Tools.	Average Breakdown Speed.	Average Volume of Metal Removed.	Improvement in Cutting Qualities of Tools.
Cub. ft. per min.	Gallons per hour.	min. sec.	ft. per min.	cub. in.	per cent.
0·1701	63·64	23 10	73·0	362·7	87

As an addendum to the above, experiments were made with compressed air as the cooling medium. In these tests the air was compressed to a gauge pressure of 50 lb. per square inch, and then conducted from the receiver through a ½-in. pipe 45 yards long, this pipe terminating in a length of rubber-and-canvas hose-pipe, which carried at its outer end a steel nozzle of ½-in. bore. The air, which was on the moist side, was projected directly on the turning and nose of the tool at the place where the turning left the bar, as shown by the arrow D in Fig. 88. The test conditions, other than in regard to the method of cooling, were precisely the same as those of all the other coolant tests on the mild-steel bar A. That is, the speed-increment test was adopted with an initial cutting speed of 50 ft. per minute and minute speed-increments of 1 ft. per minute. The results of these tests are given in Table 24, from which it will be seen that this method of cooling the turning and the tool is not apparently as effective as the method which involves the use of water as the cooling agent. Its chief virtue would appear to be that the use of compressed air is considerably cleaner than the use of water, whether the latter is used with soluble oil or soda in solution or not. On the other hand, it is objectionable on account of the noise which is caused by the emission of the air in the volume and at the velocity necessary to secure any appreciable cooling effect.

TABLE 24.—*Results of Tests with Compressed Air as Coolant.*

Direction of Flow: D (Fig. 88) on Turning and Nose of Tool.

Starting Speed = 50 ft. per minute. Area of Cut = ¼ in. deep × $\frac{1}{16}$ in. feed.

Average Life of Tools.	Average Breakdown Speed.	Average Volume of Metal Removed.	Improvement in Cutting Qualities of Tools.
min. sec.	ft. per min.	cub. in.	per cent.
16 17	66·0	236·1	22

Further tests were made with this method of cooling the tool and turning, but with this method in combination with the water-cooling method. The rate of flow of water which was used was 0·1053 cubic feet per minute (39·40 gallons per hour), whilst the direction of the flow was upwards (*vide* Fig. 88 at B). The results of these tests, whose other conditions were as above, are given in Table 25.

It will be noticed that this percentage gain is less than the sum of the percentage improvements in the cutting power due to the individual streams, which sum is equal to (70 + 22) or 92 per cent. This may be partly accounted for by the slight spreading of the stream of water which is caused by the rapidity of the movement of the air as it impinges on the turning and tool. It will be further noticed that this combination is not quite as effective as the water—water combination of directions A and B, the comparison being a gain of 81 per cent. against one of 87 per cent. respectively.

Regarding the average effect of a stream of water as a cooling agent on the cutting power of ordinary high-speed lathe turning tools, the above results give an improvement or gain of 50 per cent. which compares with the 40 per cent. increase in cutting speed attributable to the same cause as given by the late Mr. F. W. Taylor.*

TABLE 25.—*Combination of Water and Air as Coolants for Turning Tool.*

Directions of Streams: B (Fig. 88) for Water, and D (Fig. 88) for Air.

Starting Speed = 50 feet per min. Area of Cut = ¼ in. deep × $\frac{1}{16}$-in. feed.

Flow of Water.		Average Life of Tools.	Average Breakdown Speed.	Average Volume of Metal Removed.	Improvement in Cutting Qualities of Tools.
cub. ft. per min.	gallons per hour.	min. sec.	ft. per min.	cub. in.	per cent.
0·1053	39·40	22 55	72·7	351·5	81

Fig. 90. LATHE-TOOL COOLING TESTS.

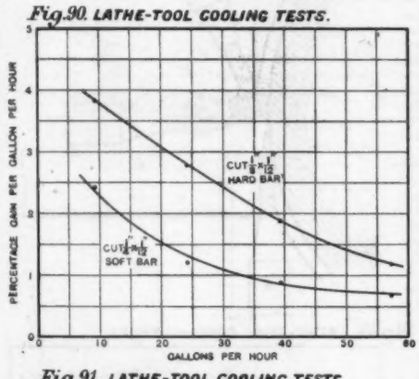
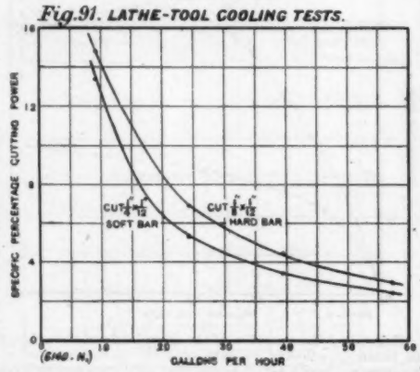


Fig. 91. LATHE-TOOL COOLING TESTS.



11.—INFLUENCE OF THE USE OF A COOLANT ON THE NET POWER CONSUMPTION WITH HIGH-SPEED LATHE TOOLS.

It has been stated that the use of a cooling medium in lathe roughing operations with high-speed tools results in an appreciable reduction in the power consumed, other things, of course, being equal, a reduction of about 40 per cent. being reported in one case. To test this point a number of tests have been made with high-speed roughing tools of various sections working on steel bars of several qualities, but no such large reduction has been observed, and, as a matter of fact, no appreciable reduction at all has been registered. The coolant (which was the above water and soluble oil mixture) was projected on the tool and turning in each of the directions A and B, Fig. 88, but in every case both the net and gross power-consumptions were respectively the same as when the tool was worked dry. This seems to point, in case of external single-edged cutting tools, to the fact that the coolant does not act as a lubricant between the chip or turning and the lip of the tool, a result which appears to be quite reasonable in view of the enormous pressure which exists between these two elements.

The only functions of the cooling medium in roughing-out operations appear, therefore, to be that of cooling the turning and retarding the rate of heating of the nose of the tool. This latter function has probably an influence upon the rate of grooving the lip surface of the tool, and this in turn appears largely to be the determining factor in connection with the durability and cutting power of a lathe high-speed roughing tool.

* Proceedings, A.S.M.E., Vol. 28, No. 3, page 140.

12.—CONDITION OF CUTTING EDGES OF HIGH-SPEED TURNING TOOLS WITH RESPECT TO EFFICIENCY OF CUTTING.

It has been suggested that a reasonable deduction from the results and observations of high-speed turning tool tests is that extreme sharpness of the cutting edge is not an essential condition of the efficient removal of metal from a steel test-bar or work-piece. To test the validity of this contention, comparative tests have been made with sharp-edged tools and tools with artificially blunted edges. In these tests, apart from this one difference, all the tools were similar, and each tool was tested in precisely the same way. At a cutting speed of 26 ft. per minute on the mild-steel test bar, A, the blunted tools tore rather than cut the metal from the bar, the cutting action being generally very unsatisfactory. Furthermore, the thickness of the chips removed was much less than that of the chips removed by the sharp tools with the same feed and depth of cut. At a cutting speed of 75 ft. per minute, the blunt tools cut much better than at the lower speed, but even at this speed their cutting action was not all comparable with that of the sharp tools on the same bar. Furthermore, the resistance to cutting at the edges of the blunt tools was so great that these tools were progressively pushed away from the test-bar.

The deduction to be drawn from these results is that a sharp cutting edge is a *sine qua non* in connection with the efficient working of a high-speed roughing tool on plain-carbon steel, and that as the bluntness of the edge is increased the efficiency of the cutting action of the tool is reduced. A further deduction is that the effect of the bluntness of the cutting edge of a high-speed tool working on a plain carbon steel work-piece is less pronounced at high cutting speeds than at low ones.

In connection with the machining of the more modern alloy steels with heavy cuts at low speeds, it is often found that there is a building-up effect on the cutting edge of a high-speed steel tool which is not very different from that which occurs with plain-carbon steel tools working with lighter cuts on plain-carbon steel work-pieces. A tool so built-up will generally continue to cut although the real cutting edge of the tool may be comparatively blunt, but a point is always reached when the real cutting edge of the tool is too blunt to sustain the built-up edge, with the consequence that efficient cutting ceases. Before this point is reached, however, if the tool is withdrawn from the work-piece, it is generally found that, if the cutting edge shows signs of a real blunting effect jointly on the flank and lip surfaces, the cutting action of the tool cannot be restarted to produce satisfactory result with the cutting edge in that condition. This is particularly the case if the machined surface against which the unground tool is fed is superhardened and polished, even only partially as sometimes it is when only a portion of the active part of the cutting edge has reached the limiting degree of bluntness.

On the other hand, a high-speed steel tool with a very sharp cutting edge, as distinct from a keen tool angle when working on a hard variety of alloy steel, such as, for example, a high nickel-chromium steel, in the annealed or normalised state, the turnings show signs of the occurrence of complete fracture in shear, and they leave the bar in the form of comparatively short chips, fairly heavy vibrations being, as a result, set up in the bar and the machine. This effect, however, is toned down as the cutting proceeds and the extreme sharpness of the cutting edge of the tool is worn off.

This should not be taken as an argument against the necessity of a sharp cutting edge on the tool, since cutting in such a case will not proceed if the cutting edge at the commencement of the cut is blunt even to a slight extent.

CONCLUSIONS.

1.—That there is no practical cutting speed below which it is impossible to obtain a satisfactory surface on plain-carbon steels by means of ordinary lathe finishing tools, whether these be made of plain-carbon tool steel, ordinary (non-vanadium) high-speed steel, or superior (vanadium) high-speed steel. There is, however, a maximum limiting speed at or above which a satisfactory finish cannot be obtained on account of the tendency of the tool to pluck at and tear the surface, this tendency being related to the phenomenon of building-up on the cutting edge of the tool. For the finishing of mild steel, this limit is not very different for each of the above three varieties of tool steel and is within the range of 48 ft. to 58 ft. per minute. For the finishing of hard steel, this limit does depend somewhat on the variety of tool steel which is employed and is within the ranges of 23 ft. to 28 ft., 17 ft. to 21 ft., and 28 ft. to 34 ft. per minute for the three varieties of tool steel respectively.

2. The durability or life of a lathe finishing tool whether of plain-carbon or high-speed steel, is for all cutting speeds below the limiting speed some function of the reciprocal of the cutting speed; in other words, an increase in the cutting speed below the limiting value is always accompanied by a decrease in the life or durability of the tool.

3. The most suitable angle of side rake (that is, the angle of side rake associated with maximum durability and cutting power) for a high-speed lathe roughing tool working on steel depends upon the physical properties of the steel. For mild-steel turning, it lies between 20 and 25 deg., whilst for hard-steel turning, it is of the order of 10 deg.; and if these angles are either increased or reduced there is always a depreciation of cutting power.

4. The colour of the turnings formed by a high-speed lathe roughing tool when working on steel is not necessarily a true index of the condition of maximum cutting efficiency. Thus, in the case of hard-steel turning, the turning colour which is associated with maximum cutting efficiency is a pale blue, whilst a mild-steel turning which is removed under the conditions of maximum efficiency

is practically uncoloured, apart, of course, from the natural grey colour of the steel.

5. The net power consumption of a high-speed roughing tool is dependent, other conditions being constant, upon the amount of top-rake on the tool, the relation between these two quantities being reciprocal in character, so that, within the limits of ordinary practice, a reduction in the top-rake angles of a tool is always accompanied by an increase in the net amount of power consumed. The law connecting the variations of the two quantities appears to be of the nature of a straight line law for all qualities of steel machined. There are, therefore, no critical values of the rake angles in regard to power consumption as there are in regard to durability and cutting power.

6. The cutting power of a high-speed lathe tool is influenced by both the cross-sectional area of the shank of the tool and the nose-radius, but the influence of the latter factor very largely predominates in all cases. Thus with a number of different sections of tool steel, an increase of the nose-radius of 100 per cent. produced an average increase in the cutting power of 45 per cent.; whereas an increase of the cross-section of the shank of the tool of 500 per cent. with a constant nose-radius produced an average increase in the cutting power of only 8·5 per cent.

7. The effect of raising a roughing tool so that its cutting edge is slightly above the horizontal plane passing through the lathe centres is, generally, to increase the cutting power of the tool slightly and to reduce its net power consumption slightly, when compared with its normal position, that is, with its cutting edge at the same height as the lathe centre axis.

8. Forging the nose of a lathe cutting tool does not materially affect its cutting power and durability, there being practically nothing to choose between a completely ground tool and a forged and ground tool, otherwise identical.

9. The general direction and the active length of the cutting edge of a high-speed tool have a slight influence upon the net power consumption of the tool, the influence being such that, with any given depth of cut, if the active length of the cutting edge is increased by an alteration of the general direction of the edge, the net power consumed is increased under conditions of working otherwise identical.

10. There is no marked difference in the net amounts of energy required per cubic inch of material removed from mild-steel and hard-steel bars at high and low cutting speeds.

11. The increase in the cutting power of a high-speed roughing tool resulting from the use of a given stream of water as a cooling agent is greater with small cuts than with heavier ones, indicating that, with heavier cuts, heavier flows of coolant should be used. The velocity of flow of a stream of coolant does not very materially affect the improvement in the cutting power of a tool due to the use of the coolant, provided that the velocity is not such as to cause excessive splashing of the coolant.

12. The cutting efficiency of a high-speed roughing tool depends very largely upon the condition of the cutting edge of the tool, and though a tool with its cutting edge blunted in the cutting process may continue to cut, it cannot be used in that condition for the purpose of starting a new cut.

In closing, the Author wishes to acknowledge his indebtedness to Professor W. Ripper, C.H., D.Eng., D.Sc., for the interest which he has taken in this work and for the facilities which have been placed at the disposal of the Author to enable the work to be done.

APPENDIX VII.

Chemical Compositions of Test-Bars.

Letter of Identification.	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.	Nature of Steel.
	per cent.	per cent.	per cent.	per cent.	per cent.	
A	0·29	0·100	0·42	0·037	0·028	Mild Steel.
B	0·39	0·075	0·50	0·030	0·038	Medium Steel.
C	0·60	0·249	0·83	0·053	0·030	Hard Steel.
W	0·23	0·027	0·45	0·025	0·025	Mild Steel.
Z	0·82	0·030	0·36	0·032	0·040	Very Hard Steel.

APPENDIX VIII.

Physical Properties of Test-Bars.

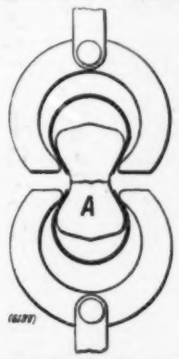
Letter of Identification.	Breaking Load.	Elongation.	Compressive Load.	Brinell Hardness Numeral.	Shore Scleroscope Value.
	tons per sq. in.	per cent.	tons per sq. in.		
A	27·2	28·4	81·2	131	22
B	33·5	21·7	90·0	146	24
C	50·5	12·0	126·4	223	33
W	24·8	28·8	74·8	126	21
Z	51·2	9·3	128·0	241	40

BRITISH ENGINEERING ACTIVITIES IN PERU.—M.H. Commercial Secretary at Lima, says *The Board of Trade Journal*, convened a meeting of engineers recently for the purpose of instituting a Local Standards Committee of the British Engineering Standards Association, in view of the association's valuable efforts in the general development of British trade overseas. H.M. Commercial Secretary was elected Hon. President of the Committee, and General Cooper, local manager of the Peruvian Corporation (which operates the greater part of the railways in Peru), chairman.

SOME HIGH TEMPERATURE TESTS OF REFRACTORIES.

THE paper on "The Measurement of Physical Properties at High Temperatures," which Mr. A. George Tarrant, B.Sc., A.R.C.S., brought before the Faraday Society on Monday, December 15, described several simple apparatus which Mr. Tarrant constructed for tests to be conducted in works laboratories. The apparatus, some of which had not assumed definite shapes when the war interrupted his investigations, were primarily designed for the testing of refractory materials, especially crucible graphite, which contains a considerable proportion of clay substance. Mr. Tarrant was for some time on the staff of the National Physical Laboratory, and some of his devices, the spiral graphite tube of Dr. J. A. Harker, the graphite-ring furnace of Dr. Rosenhain, and the furnace casing of uralite and sheet iron jacket held together by iron tie rods, due to Dr. Greenwood,* will be familiar to our readers from our comments on the work of the Laboratory. A great deal of work has been done on refractory testing during late years, notably by Dr. E. Griffiths at the National Physical Laboratory, but Mr. Tarrant was not in a position to give the numerical results of his researches which he is resuming. But practical men generally will be as interested in his paper and in the clever expedients he has adopted to overcome difficulties, as were the audience present at the meeting.

In measuring the thermal expansion of refractory materials Mr. Tarrant made use of cylindrical specimens, 4 in. long, ¾ in. diameter, which he placed axially within a tubular electric furnace, made of graphite. On the top of the cylinder, still within the furnace tube, rested a plunger, also of graphite, several times the length of the specimen; this plunger rod was of smaller diameter than the specimen, but provided with baffles to stop convection currents in the tube. To the top of the plunger was fitted a brass cap carrying an upright knife edge of steel. This edge penetrated through the central hole in a brass cap closing the upper end of the graphite tube, itself supporting a second knife-edge; the latter knife-edge served as fulcrum for a horizontal lever. As the distance between the two knife-edges was ¼ in., a lever



of 4 in. length gave a considerable magnification so that the expansion could be read to 1 part in 10,000. In fixing the caps mentioned threaded ferrules were cemented on the graphite, and the caps then screwed on the ferrules. In order to prevent the air from gaining access to the furnace tube, which was wound with nichrome wire, as well as to secure continuity of thermal conditions, the lower portion of the furnace was surrounded with conical graphite rings, themselves heated; the hot graphite giving off carbon monoxide and so providing a reducing atmosphere. Very concordant results were obtained, the temperatures being measured with a thermocouple and a thread recorder of the Cambridge Scientific Instrument Company, or for temperatures exceeding 900 deg. C. with the aid of a Holborn-Kurlbaum optical pyrometer. Attempts to use blank test pieces, cut from materials of known expansion, were not successful, because the expansion coefficients at high temperatures are very uncertain; fused silica standard specimens did give satisfaction, however, and indeed proved more sensitive indicators than the thermocouple and recorder.

For the determination of the tensile strength of refractories at temperatures up to 1,800 deg. C., a tubular furnace made with a spiral cut from a solid rod of Acheson graphite, was used. The spiral was held between an upper and a lower gun-metal electrode, both water-cooled; the lower electrode was a close push-on fit on the spiral, the upper electrode was made slightly conical so that the spiral rested in it by its own weight. As there were difficulties in obtaining sound castings, the upper electrode was cast in two parts which were brazed together. The furnace casing, made of uralite held together by iron tie-rods, was packed with lamp-black. The furnace was run on a 105-volt circuit with currents of 120 amperes and was regulated by means of two carbon-plate rheostats, geared together by a chain and sprocket wheel, this theoretically unstable arrangement giving full satisfaction. The high voltage called for a rather thin carbon spiral, and the brittle material caused troubles, which were neatly overcome. To insert the spiral into the furnace casing it was mounted on a split cardboard tube, which was afterwards burnt away by heating the spiral. When a spiral cracked, it was repaired *in situ* while under current by touching the fracture with a paste made of finely-divided graphite and synthetic resin, made of phenol and formaldehyde or similar materials. The paste softened, ran into the crack and, carbonising there, joined the fractured ends. The first repair of this kind was risked as a desperate attempt to save a spiral when work was pressing; the experiment was unexpectedly successful, and most of the work was subsequently done with a spiral which had four times been repaired in this way.

Inside the spiral was mounted a liner consisting of a gas-carbon tube, 28-mm. internal diameter and 5 mm. thick. The test bar itself, 30 in. long, ¾ in. diameter, was suspended axially in the liner by a chain and loaded below through a short chain, by means of a sand bucket. The ends of the furnace were closed round the bar with asbestos paper and loosely-packed magnesia; coal-gas was passed up the tube into the annular space, through a ⅛-in. pipe; through a hole in the bottom plate, closed by a microscope glass. A Holborn-Kurlbaum pyrometer was focussed on the side of the hottest part of the specimen.

The clamping of the specimen also gave rise to difficulties. When screwed up loosely, the clamps slipped; when tightened up, they crushed the specimen. Finally the end of the bar was armoured with a shoulder made by rolling round the bar a linen bandage, wet with a strong solution of sodium silicate, and then drying this wad in a warm room; the resulting shoulder would easily sustain a pull of several hundredweights.

As several test bars broke outside the hot zone of the furnace, a semi-circular groove of ¼ in. depth was cut round the middle portion of the bar. Such bars broke with fair regularity, the tensile strength increasing with rising temperature up to about 1,500 deg., when the strength fell off rapidly. The results—which refer only to refractories strongly heated for the first time, it should be understood—suggested that the high temperature test was less important for many refractories than a low-temperature test would be. As long as the article was strong enough to bear handling when air-dry, to stand up in the kiln and to carry its working load soft-burnt, it would probably bear the working stress at temperatures up to 1,600 deg. For many stock articles, at any rate, the factor of safety at high temperature appeared more than ample. Hence a low temperature test after the manner of cement testing was adopted. Specimen pats of 8-shape were prepared, air-dried and soft-burnt, and tested by means of a spring balance; the rounded jaws of the machine were provided with stiff iron pads so as to distribute the pressure of the jaws evenly over the specimen (see diagram annexed). This simple test proved of practical value, especially during the war-time pressure, and was substituted as a routine test for the high temperature test which was reserved for occasional use.

The work on the thermal conductivity tests of refractories was interrupted by the war and remains in a preliminary stage. Mr. Tarrant first built his apparatus up of the following superposed parts: A cooling block, test-piece of disc shape, electric-heater plate, another specimen, cooling block, and load on the block; thermo-couples were placed on the four surfaces of the two specimens. The heater was a clay tile, ¼ in. thick, 3½ in. diameter, provided with a spiral groove in which nichrome wire was placed and covered with a material of the composition under test; these heaters or their wires broke down at high temperatures. The specimen was then put on an iron plate which was gas-heated from below, a guard ring and a cooler resting on the specimen; but concordant results could only be obtained as long as all disturbances, even mere replacement of the thermo-couples, were avoided. Methods of securing better results suggested themselves, but war broke out and stopped the researches. Meanwhile comparative results, even if rough, being required, Mr. Tarrant contented himself with a simple Ingenhausz test. He placed the bar specimen, 8 in. long, ¾ in. diameter, inside an iron casting in which lead was melted. When this apparatus was inconvenient, tray-shaped specimens were prepared, ¼ in. thick at the bottom, 2½ in. in diameter, and put in an iron plate heated from below. A standard weight of lead was cast in each of these trays, and the time was observed which the lead took to melt. This latter test really depends upon the heat capacity, of course, not upon the conductivity. In the former case thermoscopic substances had to be put on the bar or pellets of such substances dropped into holes made in the bar; such substances were wax, anthracene, lead and tin.

* Captain H. C. Greenwood's premature death, we add with sincere regret, was announced at the meeting. He was an engineering chemist of great ability and originality as well as modesty; during the war he was chiefly engaged in the study of nitrogen fixation at the Munition Inventions Department.

LONDON UNIVERSITY.—At a meeting of the Senate of London University held on Wednesday, the 17th inst., the Vice-Chancellor announced that Sir Richard Glazebrook, F.R.S., had accepted the Zaharoff Chair of Aviation, tenable at the Imperial College of Science and Technology. It will be remembered that Sir Basil Zaharoff made a donation of 25,000*l.* to the university for this Chair.

HILL'S PORTUGUESE-ENGLISH DICTIONARY.—Hill's series of vest-pocket dictionaries has recently received the addition of a Portuguese-English and English-Portuguese dictionary, giving also conversations and idioms, by Leonora de Alberti. It measures about 5½ in. by 2½ in., and contains 204 pages. It is carefully got up and neatly printed. At the present time, when extension of trade is being sought between this country and both Portugal and Brazil, this handy dictionary will prove a valuable help to both English-speaking and Portuguese-speaking business men. It is issued at the price of 2*s.* net by Mr. Leopold B. Hill, 2, Langham-place, W. 1.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

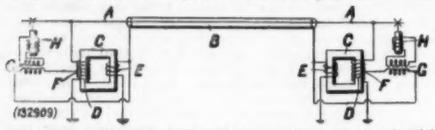
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

ELECTRICAL APPARATUS.

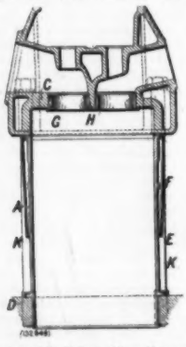
132,909. Electrical Improvements, Limited, Newcastle-upon-Tyne, and J. R. Beard, Benton. Distribution Systems. (4 *Figs.*) October 12, 1918.—This invention has special reference to the protection of high-voltage cables which are provided with what are usually known as "grading sheaths," which are disposed in the insulating material surrounding the high-voltage conductor or core, and are maintained at a predetermined voltage relative to the voltage of the conductor or core. According to this invention, there is provided in combination with the grading sheath, apparatus at one or both ends of the cable for producing in another conductor, such, for instance, as a reactance or resistance, a potential equal to that of the sheath the equipotential points being connected in a circuit which controls apparatus for cutting out the cable or conductor when a fault occurs and upsets the balance of potential between



the grading sheath and the point normally at equal potential to which it is connected. A represents a high-voltage cable provided with a grading sheath B. At each end of the conductor A is a transformer C having one end of its primary winding D connected to the conductor A and the other end earthed or connected to neutral. The secondary winding E is similarly connected to the grading sheath B, and to earth. Thus in this case the secondary winding E will raise the grading sheath B to the desired potential. Connected between the grading sheath B and a tapping point F on the primary winding D normally at a potential equal to that of the grading sheath B, is a relay G which controls a circuit-breaking device H acting to open the circuit of the conductor A. Alternatively the secondary winding E may be connected between the grading sheath B and the conductor A. (*Accepted October* 8, 1919.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

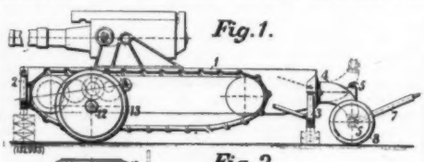
132,848. D. Napier and Son, Limited, London, and A. J. Rowledge, London. Internal-Combustion Engines. (2 *Figs.*) September 20, 1918.—This invention relates to cylinders of the type in which the casting which forms the head of the cylinder is detachable and comprises a water jacket for the head and adjacent parts which has no direct connection with the jacket surrounding the body of the cylinder. According to this invention, a water-jacketed integral casting formed of aluminium or aluminium alloy constitutes the heads of two or more cylinders, the valve seats H and inlet and exhaust

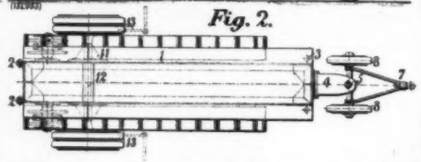


passages being arranged in this casting, the underside of which is constructed to make a gastight joint with the ends of the cylinders. The cylinders A, which are separate, are open at both ends and externally flanged at one end to make a gastight joint with the head casting G, while at the other ends the cylinders are flanged to engage the crank-case D. Bolts K extend from the crank-case to the head casting and serve to secure the casting on the separate cylinders, and to keep the latter in place. The casting is preferably recessed so that the combustion space of each cylinder is formed by and lies within this casting. An external flange E is conveniently provided at some intermediate point in the length of each cylinder, and to this flange is secured the lower part of a sheet metal casing F forming the water jacket for the body of each cylinder. The upper part of this water-jacket casing is secured to the flange at the upper end of the cylinder. External water passages are arranged between the separate cylinder jackets, and as the underside of the water space in the head casting is completely closed, the inlets and outlets for water to and from the head casting and the jackets of the cylinder bodies unite in common delivery and escape passages arranged preferably at the ends of the group of cylinders. If desired the cylinders may all be enclosed in a sheet-metal casing, which will constitute a common jacket for all the cylinders in the group in place of separate jackets being provided as above-mentioned for each cylinder. (*Accepted October* 8, 1919.)

GUNS AND EXPLOSIVES.

132,993. Compagnie des Forges et Acieries de la Marine et D'Homecourt, Paris. Endless-Track Gun Carriages. (2 *Figs.*) June 5, 1917.—This invention relates to endless-track gun carriages. 1 is the endless-track gun carriage provided at the front and rear with screw jacks 2 and 3 hinged to the carriage in such a way as to admit of being moved out of the way when travelling. In rear of the gun carriage there is a trail support 4, mounted on a pivot. This support is provided at its free end with a pivoting fork 5, 5, capable of receiving the axle of a limber 7 provided with wheels 8, and with a coupling ring. The connection between the curved trail member 4 and the axle is effected by means of a pin and fork 5, 5. At the front of the gun carriage a bearing 11 is provided, intended for the purposes of receiving an axle 12, upon which are mounted the detachable road wheels 13. In order to pass from the road position to the position for travelling over uneven ground, the operation is effected in the following manner: The screw jacks 2 and 3 are

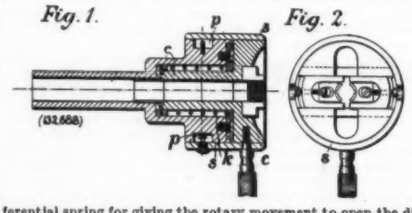




lowered as indicated in Fig. 1, and operated so as to raise the gun carriage as a whole high enough to permit of the front wheels 13 being placed on the axle 12. At the rear, the swivelling support 4 is lowered to the ground, and the limber is brought near so as to place the axle of the limber 7 underneath the pivoting fork 5. The screw jack 3 is then worked to lower the gun carriage, bringing the wheels on the axle of the limber and the pivoting fork 5 into engagement in order to permit of their being connected by means of the pin. The screw jacks 2 and 3 can then be operated afresh so as to become disengaged from the ground and put back into their travelling position. In this position the gun carriage then rests on its wheels 8 and 13, and may be coupled on to any tractor by means of the coupling ring. For the purpose of actuating the road wheels by means of the driving motor of the device, clutch mechanism is provided whereby the motor may be disconnected from the mechanism driving the endless tracks and thrown into engagement with mechanism through which the road wheels are rotated. (*Accepted October* 8, 1919.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

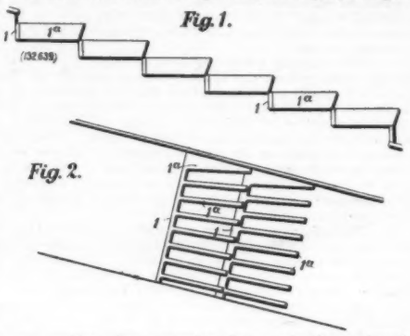
132,688. F. Mountford, Northfield, and R. Standen, Small Heath, Birmingham. Die Heads for Screw Cutting. (8 *Figs.*) December 16, 1918.—This invention comprises improvements in and relating to die heads for screw cutting. In the improved die head for crew-cutting machines the die head is chambered at the front to accommodate a spigot or stem *c* of the die holder *c*, the spring *k* for axially moving the holder being arranged around the spigot or stem in said chamber. A groove *p* in the periphery of the die head accommodates the circum-



ferential spring for giving the rotary movement to open the dies when axial movement between the die head and die holder takes place. A cylindrical cover *s* is carried by the die holder to enclose the parts and the groove containing the circumferential spring. The cylindrical covers provide the anchorage for one end of the spring for giving the relative rotary movement between the holder and the head, the spring being arranged so that it may be reversed in position with regard to its anchorage so that the die head may be readily adapted for right or left-hand screwing. (*Sealed.*)

MINING, METALLURGY, AND METAL WORKING.

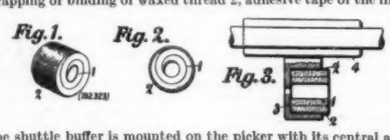
132,639. Babcock and Wilcox, Limited, London, and A. Lennox, Acton, London. Screening Coal. (2 *Figs.*) October 4, 1918.—This invention relates to apparatus for screening coal of the type comprising a trough, the bottom of which is constituted by stepwise-arranged gratings formed in segments or in one piece, and each presenting a horizontal or inclined surface, the discharge end of one grating being immediately above the receiving end of the grating immediately following, so that the material flows cascade fashion over the stepped surface, each grating comprising bars extending substantially in the direction of flow, but arranged fanwise or slightly divergent



to one another. The apparatus shown comprises a trough, the bottom of which is constituted by stepwise-arranged gratings 1, the discharge end of one grating being immediately above the receiving end of the grating immediately following, the arrangement being such that the material flows cascade fashion over the stepped surface. Each grating comprises bars 1a extending substantially in the direction of flow, but divergent to one another, so that the bars of each grating become wider apart in the direction of flow. The cross-section of the bars 1a is such that the upper face of each bar is of greater area than the under face, *i.e.*, the bars are of substantially wedge shape in cross-section, so that the gap between any two bars widens downwardly. (*Sealed.*)

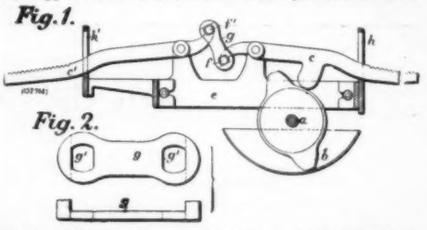
TEXTILE MACHINERY.

132,323. A. Newton-Smith, Westminster, London. Shuttle Buffers. (5 *Figs.*) September 6, 1918.—This invention has relation to the leather buffers provided on metal pickers for receiving and deadening the impact of the shuttle. In accordance with this invention, a shuttle buffer comprises a strip or piece of leather 1 folded or wrapped into a spiral, coil, snail or roll with a central longitudinal hole and maintained in such form by a wrapping or binding of waxed thread 2, adhesive tape or the like.



The shuttle buffer is mounted on the picker with its central and longitudinal hole in the line of movement of the shuttle, so that when the shuttle strikes the buffer, its tip enters the said hole. The shuttle buffer described may be mounted in any suitable construction of picker. In Fig. 3, the shuttle buffer is contained within an open-ended cylinder 3 depending from the picker body 4. The binding or wrapping 2 assists in holding the buffer within the cylinder. (*Sealed.*)

132,714. J. Heatley, Blackburn, and C. Field, Blackburn. Loom Shedding Motions. (3 *Figs.*) February 19, 1919.—In the shedding motion of a loom for weaving, having a pin and link connection, the holes in the links which embrace the pins are formed approximately square with rounded angles, in order to obtain a rolling motion and minimise friction in the connections. *a* designates the tappet shaft which is driven in the usual way; *b* the tappets or risers; *c*, *c1*, the jacks or lifting levers fulcrummed



near one end on the framework *e*; *f*, *f1*, pins on the jacks *c*, *c1*, respectively; *g* the improved link; and *h*, *h1*, the gratings in which the jacks or lifting levers *c*, *c1*, work, and by which they are spaced and guided. On referring to the detailed views, Fig. 2, it will be clearly seen that according to this invention the usual holes *g1* in each link *g* are formed approximately square, with rounded angles, so that the motion imparted by the tappets *b* to the inner jack or lifting lever *c* is transmitted in the form of rolling motion to the outer jack *c1*. (*Sealed.*)

THE END OF THE ONE HUNDRED AND EIGHTH VOLUME.

Assistant Civil Engineer, for West of England, with good Dredging experience, including submarine rock removal by boring and blasting, also by Lobnitz Breaker.—Write, BOX D. F., c/o W. S. CRAWFORD, LTD., 35, Fetter Lane, E.C. 4. C 224

Central Electric Power Station, abroad, has VACANCY for first-class Steam ENGINEER to take charge of operation of battery of Babcock & Wilcox boilers, having all modern auxiliaries with oil-fuel burning installation and turbo-generators of 9000 Kw. capacity. Candidates must be first-class mechanics with technical education.—Address, C 494, Offices of ENGINEERING.

Messrs. Handley Page, Ltd., REQUIRE the SERVICES of an EXPERIMENTAL ENGINEER in charge of their wind channel and aerodynamic testing work. Applicants must have had similar experience at the N.P.L. or elsewhere, be able to initiate and carry through research work and be well acquainted with aeronautical technology.—Full details as to past experience, age, salary required must be stated in writing to EXPERIMENTS, care of Messrs. HANDLEY PAGE, Ltd., Cricklewood, London. C 233

North China.—Experienced Civil ENGINEER REQUIRED to superintend alterations and lengthening of Dry Dock. It is essential that he should already have had similar experience. The undertaking will probably last 12 months. State previous experience, age and salary wanted, to DOCK, care of ABBOTT'S, Eastcheap, London, E.C. 3. C 431

Engineer.—A Large Engi- neering concern in the North, REQUIRES an ENGINEER to assist in the management of a section of the works concerned in the working up of copper, sheet metal and the drawing of metals. To those who have successfully held positions of authority in engineering works in the classes of work mentioned the vacancy offers good prospects. —Address, full particulars, C 433, Offices of ENGINEERING.

Foreman (Toolroom) for High CLASS WORK; must have had extensive all round experience, and good at figures. None but very first-class men will be entertained.—Address, stating experience, qualifications, and salary required, C 429, Offices of ENGINEERING.

Foreman Required for Small Drawbench Section of Engineering Works. Must have some experience of drawbench work, particularly steel and copper bar work. Manchester district. State age, experience (in full) and salary required.—Address, C 240, Offices of ENGINEERING.

Foundry Foreman Wanted, with up-to-date experience in the economical production of iron and brass castings up to two tons weight, for new foundry in London district.—Address, giving full particulars of experience, age and salary required to C 426, Offices of ENGINEERING.

Commercial Assistant.—Pro- gressive Office APPOINTMENT is OFFERED to capable man of about 28 to 33 years of age with good education and knowledge of modern sales organisation. Experience of rails, sleepers and other permanent way materials is a recommendation but is not essential. State age, salary desired and give full particulars of qualifications and training. —Address, C 392, Offices of ENGINEERING.

Leading Draughtsman, Experienced in cranes or similar work, preferably aerial ropeways. State full particulars of experience, age and salary.—Address, C 217, Offices of ENGINEERING.

Wanted, at once, as Assistant to Chief Designer, capable DRAUGHTSMAN with up-to-date experience of first-class Automobile design, also leading Draughtsmen with similar experience. Glasgow district. Address, C 224, Offices of ENGINEERING.

Draughtsmen with Automatic Machine experience, must have had shop training.—Address, stating age, experience and salary expected, C 322, Offices of ENGINEERING.

Draughtsmen Required for Jig and Tool work in large Midland Engineering Works, also Machine Tool Draughtsmen. Experienced men only need apply. State age, experience and salary required. — Address, C 318, Offices of ENGINEERING.

Draughtsman Required for Engineer's London Office. Skilled in preparing Layout drawings, of Conveying plants for coal, ore, etc., also detailers with Structural and Mechanical knowledge. Only experienced men need apply.—Address, C 424, Offices of ENGINEERING.

Wanted, Experienced DRAUGHTSMAN, with Iron and Steel Works experience preferred.—Write, giving full particulars of experience and training, stating age and salary required, to CHIEF ENGINEER, Dowlais-Cardiff Iron and Steel Works, East Moors, Cardiff. C 184

Reinforced Concrete DRAUGHTSMEN REQUIRED for Manchester. Good salaries given to useful men.—Address, stating age, salary and experience, B 943, Offices of ENGINEERING.

Wanted, in the London Area, a DRAUGHTSMAN experienced in Constructional Steelwork. State age, experience and salary required.—Address, C 417, Offices of ENGINEERING.

Draughtsman Wanted with experience in Petrol Engines for Motor Lorries.—Address, C 473, Offices of ENGINEERING.

Draughtsman Wanted by Firm manufacturing Steam Motor Vehicles. State age, experience, and Salary required.—Address, C 353, Offices of ENGINEERING.

Draughtsman for Works about 30 miles from London. Experience of I.C. engines an advantage. State age, wages and experience.—Address, C 369, Offices of ENGINEERING.

HANDBOOK OF

Ship Calculations, Construction and Operation.

By CHARLES H. HUGHES.

The ideal book of reference for Shipbuilders, Owners, Marine Engineers, Naval Architects and Draughtsmen. Assembles in a single volume of most handy size (7 in. by 4½ in. by 1 in.), practical data for everyday reference. Upwards of 700 pages of practical facts are included, the whole contents having been gathered by the author, primarily for personal everyday use.

Contents include:—Weights, Measures and Formulæ—Strength of Materials—Calculations—Hull Construction—Machinery—Boilers—Draft—Marine Steam Engines—Propellers—Paddle Wheels—Steam Turbines—Auxiliaries—Internal Combustion Engines—Piping, Tubing—Valves—Electricity—Heating, Ventilating, Refrigeration, Drainage, Plumbing and Fire Extinguishing—Equipment—Operation. Over 120 illustrations and numerous statistical tables and "graphs."

DESCRIPTIVE FOLDER **FREE.**

The Library Press Limited, 7, PORTUGAL STREET BLDGS., PORTUGAL STREET, LONDON, W.C. 2. 7849

The Broadway Engineering Handbooks.

VOLUME XIV

LATHES

Their Construction and Operation.

By G. W. BURLEY, Wh. Ex. A.M.I.Mech.E.

NARROW CROWN 8VO. 244 PAGES.

Price 4s. 6d. net (post free, 4s. 11d. home and abroad). Cash with order.

Contents sent post free on application to 7856

SCOTT, GREENWOOD & SON,
8, Broadway, Ludgate, London, E.C. 4.

SELWYN'S BOOKS FOR ENGINEERS.

DETAIL DESIGN IN REINFORCED CONCRETE ... ... 6/- net.
EWART S. ANDREWS, B.Sc.
THE STRENGTH OF CURVED BEAMS. EWART S. ANDREWS, B.Sc.... 6/- ,,
TABLES OF SAFE LOADS ON STEEL PILLARS... ... ... 6/- ,,
(Plated Single I Beams. To L.C.C. Regulations.) ANDREWS & COCKING.

For further particulars write— 8014

JAMES SELWYN & CO., LTD., 20, Essex Street, W.C. 2.

Draughtsman Wanted with first-class experience in Mining Machinery, Crushing Plants, etc.—Address, FRASER & CHALMERS' ENGINEERING WORKS, Erith, Kent. C 450

Wanted, Energetic Young DRAUGHTSMAN, capable of going out and taking own particulars for fixing Hydraulic and Electric Lifts and Cranes.—Address, C 454, Offices of ENGINEERING.

Wanted, First-class DRAUGHTSMAN, preferably with works experience of welded sheet work.—Apply, stating qualifications and salary required, to OGILVIE AND PARTNERS, LTD., 104, High Holborn, W.C. 1. C 455

Draughtsmen Wanted for Detail Work on Internal Combustion Engines.—Address, with full information, salary, etc., C 457, Offices of ENGINEERING.

Draughtsmen Wanted in Wolverhampton. None but men with first-class experience on Motor Chassis and Engine work need apply.—Address, C 459, Offices of ENGINEERING.

Leading Draughtsman for large All-Metal Flying Boat Design, with first-class knowledge of plane and boat hull stress calculations.—Address, giving full details of experience and salary required, C 461, Offices of ENGINEERING.

Leading Draughtsman with first-class knowledge of Light Metal Structural Design, Calculations and Details.—Address, giving full details of experience and salary required, C 462, Offices of ENGINEERING.

Mechanical Draughtsman for Design of Gear Boxes and Transmission of Large Flying Boats. First-class experience in Motor-car Transmission Gear essential.—Address, giving full details of experience and salary required, C 463, Offices of ENGINEERING.

Draughtsman for A.C. Wind- ing Drawings and Diagrams.—Write, stating qualifications, age and salary required, to ELECTRICAL D.O., THE B.T.H. CO., LTD., Rugby. C 480

Draughtsman, Junior, Jig and Tool, REQUIRED immediately for small engine work on production lines.—Apply, WESTLAND AIRCRAFT WORKS, Yeovil. C 471

Required, a capable Draughts- MAN with experience in Steam, Turbine and Centrifugal Pump work.—State age, experience and salary required, to W. H. ALLEN, SON & CO., LTD., Queen's Engineering Works, Bedford. C 502

Wanted, Leading Draughts- MAN, experienced in Hydraulic Machine Tools. State fully qualifications, age and salary expected. LEEDS ENGINEERING & HYDRAULIC CO., Ltd., Rodley, Nr. Leeds. C 468

Chief Draughtsman Wanted for a large and well-known Machine Tool Works in the Manchester District. He will be required to take full charge of Works Drawing Office, and must be thoroughly experienced in the design of High Class modern, light and heavy Machine Tools. The position is a permanent one and offers a good opportunity for a first-class man. State experience, age and salary required.—Address, C 467, Offices of ENGINEERING.

Designer for Marine Engines, 500 to 2000 I.HP., also Two DRAUGHTSMEN accustomed to details, WANTED immediately.—Apply, CHIEF DRAUGHTSMAN, J. SAMUEL WHITE & COMPANY, LTD., East Cowes, I.W. C 346

Wanted, First-class DRAUGHTSMAN with thorough experience in designing vertical internal combustion engines for Agricultural Tractors or Heavy Motor Vehicles. Preferably one with experience of Chassis work suitable for same.—Address, C 472, Offices of ENGINEERING.

Draughtsman Wanted in the Midlands. Capable men for Plant and Machine Design, quick, accurate workers only need apply. State experience, age, qualifications and salary required. Two or three testimonials should be enclosed with application.—Address, C 476, Offices of ENGINEERING.

Junior Draughtsman for Ex- perimental workshop in research organisation in London District (W.); general light engineering and automatic devices.—Address, stating age, experience and salary required, C 480, Offices of ENGINEERING.

Draughtsman Wanted in Constructional Works Office. Must have had a good all-round experience in steel framed buildings. One with bridgework experience preferred. State wages required, age, and when disengaged.—Address, C 503, Offices of ENGINEERING.

Draughtsman Wanted, (a) for the Design and Detail of Rolling Stock for Electric and Light Railways and the like, preferably with workshop experience; (b) for the Design and Detail of Control Gear and Wiring for Electric Rolling Stock; and (c) for the Lay-out and arrangement of Engineering Workshop Plant, "machinery, tool and general stores, etc."—Write, stating age, experience and salary required, to BOX No. 40, ANDERSON'S ADVERTISING AGENCY, 14, King William Street, Strand. C 469

SITUATIONS WANTED.

Engineer, 31, B.O.T. 1st Class Steam and 2nd Class Motor Certificates, M.I.Mar.E., ex-Warrant Engineer, R.N.R., DESIRES highly responsible POST. Internal Combustion work preferred. A "live" man, and thoroughly experienced. Free January 31st.—Address, C 391, Offices of ENGINEERING.

Mechanical Engineer, De- mobilised. Marine, stationary and locomotive experience, thoroughly practical, good draughtsman, sound knowledge of "Yardson" and "Tilan" tractors, DESIRES permanent POSITION with firm manufacturing Agricultural Tractors.—Address, C 389, Offices of ENGINEERING.

Mechanical Draughtsman DESIRES EMPLOYMENT at Reconstruction Work. Has had wide experience in the lay-out of factory plant and buildings, and general engineering.—Address, C 503, Offices of ENGINEERING.

PARTNERSHIPS

Engineers
with £5000 upwards
desirous of openings in
Established and Profitable
Works and Businesses
should apply to
WHEATLEY KIRK PRICE and CO
46 Watling Street LONDON E C 4
Albert Square Manchester 7979
26 Collingwood Street Newcastle-on-Tyne

Old-established Sheffield Firm of Steel Manufacturers is PREPARED to CONSIDER AMALGAMATION, preferably with large user of High-speed or Carbon Tool Steel.—Address, C 8, Offices of ENGINEERING.

Partnerships.—Alan Martin, MORGAN & CO., Ltd., Investment Partnerships and Company Registration Agents, INVITE CORRESPONDENCE from firms proposing to extend and requiring their services. Book, "Why every Business Man should adopt Limited Liability, its Facilities and Protection," the most explanatory and easily understood book on subject published. One shilling, post free.—10, Lower John St., Regent St., London, W. 1. C 421

PATENT AGENTS.

W. Bryson, B.Sc., Assoc.M. Inst.C.E., A.F.R.Ae.S., Chartered Patent Agent, B 365
29, Southampton Buildings, London, W.C. 2.

Jensen and Son 8079
CHARTERED PATENT AGENTS.
Established 1857). British, Colonial, and Foreign Patents, and Trade Marks and Designs Registration. 77, Chancery Lane, London, W.C. Tel: Holborn 1849

John E. Raworth & Moss, CHARTERED PATENT AGENTS, 69/71, Queen Anne's Chambers, 7978 Tothill Street, Westminster, S.W. 1.

Patents, Inventions, Trade MARKS, DESIGNS.—Advice and handbook free.—KING'S PATENT AGENCY, LIMITED, 166, Queen Victoria Street, London. Over 34 years' references. Telephone, Central 682. 8116

PUBLICATIONS.

PATENT-RIGHTS;
THEIR ACQUISITION AND MAINTENANCE.
A Concise Summary of the Principal Facts with which Inventors, Manufacturers and others, interested in the Protection of Inventions, should be acquainted.
By G. G. M. HARDINGHAM,
MEM. INST. M.E., FEL. CH. INST., F.A.
CROSBY LOCKWOOD & SON, 7813
7, STATIONERS' HALL COURT, LONDON, E.C.
Revised Edition, price 1s. 6d.; by post, 1s. 8d.

WANTED, &c.

Designs, Drawings, Tracings. —Working Drawings made from Clients Sketches and Instructions. Single Purpose Machines Designed. Drawings Prepared for Patent Specifications and all Classes of Tracing Undertaken. Jig and Fixture Design and Mechanical Work a Specialty. Estimates given for Supplying Jigs, Fixtures and Tools.—OWEN & CHISP, Draughtsmen, 64, Basinghall Street, London, E.C. 2. 8015

Wanted, &c., continued on page 147.

For Continuation of Small Advertisements see pages 147-8-9.

BULL'S METAL & MELLOID CO.
Head Office and Works: Limited.
YOKER, near GLASGOW.
Telegrams: "Melloid, Yoker."
BULL'S METAL.—Propellers, Bars, Sheets, Pump Rods, Valve Spindles, Condenser Stays & Plates, &c.
MELLOID. (Reg. Trade Mark and Patented.)—Condenser Tubes, Plates and Stays, Boiler Tubes, Stays and Plates, Fire-box Plates, Bars, Sheets, Valves, &c.
WHITE METALS.—Babbitts, Plastic, &c. 7937

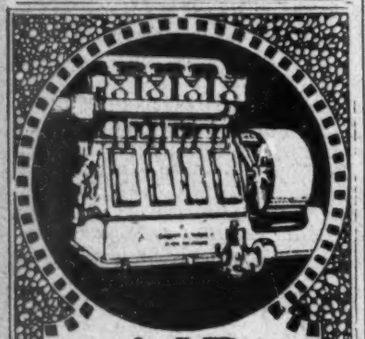
S.B. IRON
& STEEL Bars. Plates & Sheets.
STRINGER BROTHERS,
WEST BROMWICH. 7782

STEAM CRANES AND ELECTRIC OVERHEAD CRANES.
SAMUEL BUTLER & CO. LTD.
Grangefield Works, STANNINGLEY, near LEEDS.
'Grams—"Lifting, Stanningley."
'Phone—176 Stanningley Private Branch Exchange.

PHOSPHOR BRONZE, GUNMETAL AND BRASS CASTINGS. 7787
HIGH-CLASS STEAM FITTINGS.
Specialty—SHIPS' DECK FITTINGS.

JOHN McROBIE & SONS,
94, Elliot Street, GLASGOW.
On Admiralty List. Telephone: CENTRAL 1241.
North-East Coast Representative, CHAS. RUTHERFORD, North Eastern Bank Chambers, Middlesbrough.

HIGH EFFICIENCY
WORM GEARS
WALLWORK.
Manchester. 7578
DELIVERY FROM STOCK.


AIR
(5 to 1000 C.F.)
Compressors
Write for booklet, "94% Efficiency Compressors"
BROOM & WADE LTD
HIGH WYCOMBE *England*

ANTI-CORROSIVE INSULATING
PAINT
No renewals in 5 yrs. on constructional work.
"CUIRASS" PRODUCTS Ltd.,
39, Victoria Street, London, Eng.
Agents Wanted where not represented. 8108

EXTRUDED BARS
"DELTA" BRAND
BRONZE, YELLOW METAL, BRASS, RED METAL, NAVAL BRASS, COPPER, &c.
THE DELTA METAL CO., LTD., DELTA WORKS, EAST GREENWICH, LONDON, S.E. 10.
And at BIRMINGHAM. 8122

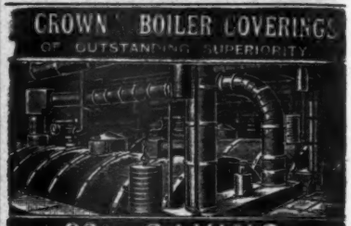
MUSGRAVE BROS.
CROWN POINT FOUNDRY, LEEDS.
ARE MANUFACTURERS OF THE LATEST AND MOST IMPROVED
HYDRAULIC PUMPS,
ACCUMULATORS,
RIVETTERS, PRESSES, VALVES
&c. &c
Illustrations and Prices on application.
6683

W. B. BROWN & CO. (BANKHALL), LD.
GLOBE WORKS. LIVERPOOL.
HIGH GRADE.
STEEL WIRE ROPES FOR ENGINEERING. 7385

There are too many advantages
to describe in this space attaching to the speedy reliability of the
"SKATOSKALO"
PNEUMATIC SCALING TOOL
for removing scale
from Babcock, Stirling and other water-tube boilers, evaporators and condensers and for Lancashire boiler scaling, rust removing, etc. But they are all given in my catalogue.
Write:
FRANK GILMAN,
Sole Maker, 9, WESTFIELD RD.,
BIRMINGHAM
7396

SAFETY in the Power House and the Workshop.
Wherever Power is used and generated, whether in buildings, on the road, at sea, or in the air, "TRIPLEX" provides a factor for safety that cannot be overestimated. Nothing can splinter it or cause fragments to fly.
WRITE FOR CATALOGUE No. 11. 7883
"TRIPLEX" Unsplinterable Safety GLASS
THE TRIPLEX SAFETY GLASS CO. Ltd.
Reginald Delpech, Managing Director
1, ALBEMARLE STREET, W. 1.
Telephone—Regent 1300 (3 lines).
Telegrams—Shatterless, Picc, London.

J. & E. HALL, LTD.,
Makers of CO_2 and NH_3
Refrigerating Machines
—and—
Hallford Motor Vehicles 7973
19, St. Swithin's Lane, London, E.C., & Dartford, Kent

CROWN BOILER COVERINGS
OF OUTSTANDING SUPERIORITY

96 SAVING
IN RADIATION—HIGHEST EFFICIENCY
SUTCLIFFE BROS.,

OXY-ACETYLENE
WELDING
AND
CUTTING PLANT
MANUFACTURERS.
COMPLETE EQUIPMENTS.
4906
McGOWAN, WILD & CO.,
Lower Hurst Street,
BIRMINGHAM.
Tel.—1516, Midland. Telg.—Logic, B'ham.

GRANT, RITCHIE & CO. LTD.
Townholm Engine Works, KILMARNOCK.
Steel Works and Colliery Plant.
Roller Racks.
Tank Locomotives. Haulages. Pumps.
Castings. Engines.

EDWARD HAYES,
Od 2174 Watling Works,
Stony Stratford.
Marine Engines
Now Ready
6 & 12 × 8 C.S.C.
7 & 14 × 9 C.S.C.
8 & 16 × 10 C.S.C.
9 & 18 × 11 C.S.C.
Boilers to Suit.
Makers to Admiralty, &c.

STOCK BOILERS.

MOST MODERN "DISH END" TYPE.
One 30' 0" × 9' 3" × 180 lbs. W.P.
One 30' 0" × 8' 6" × 160 lbs. W.P.
Two 30' 0" × 8' 6" × 150 lbs. W.P.
Five 30' 0" × 8' 6" × 120 lbs. W.P.
One 30' 0" × 8' 3" × 160 lbs. W.P.
Six 30' 0" × 8' 3" × 150 lbs. W.P.
Two 30' 0" × 8' 3" × 120 lbs. W.P.
Also other Sizes and Pressures Ready for Immediate Despatch.
John Thompson (Wolverhampton) Limited, 8121
WOLVERHAMPTON, Eng.

INDEX TO ADVERTISEMENTS.

PAGE

A. B. Diesels Motorer ..142
A-1 Manufacturing Co. ..61
Adaptable Moulding Machine Co. ..99
Aerators, Ltd ..1
Aerial Ropeways Transporters, Ltd. ..9
Allan Shipbuilding Co., Ltd. 127
Airostyle & Lithos Ltd. ..104
Aitken & Co. ..142
Albion Drop Forgings Co. 27
Aldrich Pump Co. ..120
Alexander, G. H. ..46
Alldays & Onions, Ltd. ..12
Allen, Edgar, & Co., Ltd. 128
Allen-Liversidge, Ltd. ..119
Allen, W. H., Son & Co. Ltd. 69
Almeler Bros. ..104
Anderson Grice Co., Ltd. ..142
Anderston Foundry Co., Ltd 129
Anglo-Mexican Petrium Co. 118
Angus, Geo. & Co., Ltd. ..142
Archdale, Jas., & Co., Ltd. 51
Armstrong Mfg. Co. ..106
Armstrong, Stevens & Son, Ltd. 49
Armstrong, Sir W. G. Whitworth & Co., Ltd. 64&65
Armstrongs & Main, Ltd. 98
Ash, Joseph & Son ..140
Ashmore, Benson, Pease and Co. ..134
Asquith, Wm., Ltd. ..93
Aveling & Porter, Ltd. ..1
Avery, W. & T., Ltd. ..88
Avonside Engine Co. ..135
Bailey, Sir W. H. & Co. Ltd 46
Baldwin Loco. Works ..127
Baldwin's, Ltd. ..146
Barclay, Andrew, Sons & Co. 127
Barford & Perkins, Ltd. ..107
Barker, Spink, Lunac & Co. 78
Barry, Henry & Co. ..18
Bayliss, Jones & Bayliss, Ltd. 128
Beardmore, Wm. & Co., Ltd. ..35 & 61
Beebe, A. ..109
Beldam Pkg. & Rbr. Co., Ld. 92
Bellamy, John, Ltd. ..8
Bellias & Morcom, Ld. 79 & 149
Bell's United Asbestos Co. 93
Bergius Launch & Engine Co. ..142
Bertrams, Ltd. ..143
Bessemer, Henry & Co., Ltd. 93
Bever, Dorling & Co., Ltd. 1
Beyer, Peacock & Co., Ltd. 133
Birkett, T. M., & Son ..139
Birm. Alum'n. Castings Co. 90
Bham Battery & Metal Co. 92
Bham R. C. & Wagon Co. ..106
Blackstone & Co., Ltd. ..88
Blair, Campbell & McLean 133
Blakeborough, J. & Sons, Ld. 43
Bolton, Thos. & Sons, Ltd. 144
Booth, John & Sons ..48
Booth, Joseph, & Bros., Ld. 76
Boving & Co., Ltd. ..82
Bradley Pulverizer Co. ..106
Bradley & Co., Ltd. ..8
Brandon Bridge-Building Co. 134
Brecknell, Munro & Rogers 27
Brett's Patent Lifter Co., Ltd 1
Bridge, D., & Co. ..111
Brightside Foundy. & Eng. Co. ..128
Briquette Machinery Ltd. 143
Brit. Aluminium Co. Ltd. ..1
British Chemical Ware Manufacturers Assoc. ..14
Brit. Electric Plant Co. Ld. 143
British Evertite & Asbestolite Works, Ltd. ..9
Brit. Indus. Fair (B'ham) 143
British Lighting & Ignition Co., Ltd. ..39
Brit. Mechanite Boiler Co., Ltd. ..10
British Oxygen Co., Ltd. ..144
British Rolling Mills, Ltd. 31
Brit. Steam Specialties, Ld. 16
British Steel Piling Co. ..100
B.T.H. Co., Ltd ..71
British Vac. Cleaner Co. Ltd. ..118
Briton Ferry Steel Co. Ld. 26
Bromell Patents Co. Ld. ..108
Broom & Wade, Ltd. ..4 & 108
Brotherhood, P., Ltd. ..77
Brown, Lindley & Co., Ltd. ..19
Brown Hoisting Machinery Co. ..6
Brown, John, & Co., Ltd. ..128
Brown, Lenox & Co., Ltd. 90
Brown, W. B. & Co. Ltd. ..4
Browning Co. ..119
Brownlie & Green, Ltd. ..143
Brundrit, Joseph ..148
Bucyrus Company ..106
Budenberg Gauge Co., Ltd. 141
Buring's Pat. Water Co. ..140
Bullard Machine Tool Co. 131
Bullivant & Co., Ltd. ..20
Bull's Metal & Melloid Co. ..4
Burckhardt Eng. Works 140
Burton, Dellingale & Co. ..91
Butler Jones (Nameplates) 76
Butler, J., & Co. ..101
Butler, Samuel & Co., Ld. ..4
Butterley Co., Ltd. ..123
Cameron, John, Ltd. ..86
Cammell Laird & Co., Ltd. 139
Cammie, R. E. ..8
Campbell & Calderwood ..117
Campbells & Hunter, Ltd. ..1
Cape Asbestos Co. ..9
Carron Company ..94
Chadburn (Ship) Tele. Co. 108
Chambers, Scott & Co., Ltd. 108
Chaplin, Alex. & Co., Ltd... 8
Chatwin, Thos., Ltd. ..24
Clarke's Crank & Forge Co., Ltd. ..142
Clay Cross Co., Ltd. ..128
Clayton & Shuttleworth, Ltd. ..88
Clayton, Son & Co., Ltd. 133
Cleveland Bridge & Eng. Co. 10
Clifton & Baird, Ltd. ..128
Clifton & Waddell ..29
Clyde Nail Co., Ltd. ..104
Clyde Structural Iron Co. 17
Clyne Engineering Co. ..143
Coale Machine Tool Co., 94
Cochran & Co., Annan, Ld. ..1
Cole, Henry, A., & Co. Ltd. 11
Cole Marchent & Morley, Ld 10
Coles, Henry J., Ltd. ... 111
Colley Eng. & Mach. C. 51
Coltman, W. W., & Co., Ltd. ..126
Columbia Steel & Eng. Co. 25
Colville, D., & Sons, Ltd. ..28
Commercial Cars, Ltd. ..121
Consolidated Brake & Eng. Co. ..130
Consolidated Press. Tool Co. 29
Conveyor & Elevator Co. ..9
Cooke, E. J. ..27
Cooke, T. & Sons, Ltd. ..145
Cousland, A., & Son ..10
Cradley Boiler Co., Ltd. ..121
Cradock, G. & Co., Ltd. ..112
Craig & Donald, Ltd. ..1
Craven Bros. (Manchester) Ltd. ..88
Cresswells' Ltd. ..98
Crosby Valve & Eng. Co., Ltd. ..19
Cuirass Products, Ltd. ..118
Cushman Chuck Co. ..109
Daniell, S. A., Ltd. ..130
Daniels, T. H. & J., Ltd... 140
Danks, H. & T. ..140
Darlington Forge Co., Ld. 97
Davenport Eng. Co., Ltd. 116
Davey, Paxman & Co., Ltd. 76
Davis Brothers, Ltd... ..15
Davis & Primrose, Ltd. ..1
Davy Brothers, Ltd. ..112
Dawson & Downie, Ld. ..142
Delta Metal Co., Ltd. ..4
Dempster, Moore & Co., Ltd. 144
Denison, S., & Son, Ltd. ..21
Dickie, George & Son ..131
Dobbie McInnes, Ltd. ..27
Donkin Co., Ltd. (The Bryan) 30
Douglas & Grant, Ltd. ..105
Douglas, Lawson & Co. ..29
Drum Engineering Co. ..145
Drummond Bros., Ltd. ..117
Drysdale & Co., Ltd. 10
Dublin Dockyard Co., Ld. 139
Dunkerley C. C. & Co., Ld. 98
E. Ferry Ed. Eng. Wks. Co. Ld. 8
Electric Control, Ltd. ..19
Electro-Mech. Brake Co... 122
Electro-Metals, Ltd. ..14
Electrode Co. of Sheffield Ltd. ..117
Elliston, Evans & Jackson 10
Engineering Supplies, Ltd. 10
English Electric Co. Ld. ..96
Entwisle & Gass, Ltd. ..147
Escher, Wyss & Co. ..10
Evertit & Co. ..125
Expanded Metal Co., Ltd. 94
Fairley, James, & Sons ..104
Ferguson Bros., Ltd. ..47
Fielding & Platt, Ltd ..41
Fife Forge Co., Ltd. 24
Figee, Ltd. ..16
Findlay, Alex. & Co., Ltd. 10
Firth, Thos., Ltd. ..24
Fisher & Ludlow, Ltd. ..86
Fletcher, George, & Co., Ld. 1
Foster Brothers, Ltd. ..140
Fowler, John, & Co. (Leeds) 122
France & Morgan ..108
Fraser & Chalmers ..60
Fraser, Douglas & Sons ..142
Friendenthals, Ltd. ..109
Fry's Metal Foundry ..123
Fuller-Lehigh Co. ..118
Fullerton, Hodgart & Barclay 120
Furness, Withy & Co., Ltd. 111
Galloways, Ltd. ..13
Gardner, L. & Sons, Ltd. 39
Garrett, Richd., & Sons, Ld. 92
Gartenmeister Eng. & Forge Co. 1
General Electric Co., Ltd. 60
Gibbins, R. C., & Co. 140
Gibbons, James ..128
Gilbertson, W., & Co., Ltd. 13
Gilman, Frank, Ltd. 4
Glacier, A.-F. Metal Co. Ltd. ..14
Glasgow Iron & Steel Co., Ltd. 128
Glasgow Railway Eng. Co. Ltd. ..1
Glenfield & Kennedy, Ltd. 142
Glover, W. T. & Co., Ltd ..143
Goodwin, Barsby & Co ..10
Govan Shafting Eng. Co ..121
Grafton & Co. ..142
Grant, Ritchie & Co., Ltd 1
Graphite Products, Ltd. ..116
Graves & Co., Ltd. 19
Green & Boulding, Ltd. ..141
Gresham & Craven, Ltd. ..130
Grice, Thos., & Sons ..41
Guest & Chrimes, Ltd. ..108
Gunther, W., & Sons ..149
Gutta Percha & Rubber Ltd. 7
Gwynnes, Ltd. ... .77
Hadfields, Ltd. 76
Hall, J. & E., Ltd. 4
Hall, J. P., & Sons, Ltd. ..106
Hall, Walker & Co., Ltd. ..7
Hamworthy Eng. Co. Ltd. 107
Hannan & Buchanan ..148
Harris Patent Feed Water Heater Co., Ltd. ..108 & 148
Hartley & Sugden, Ltd. ..122
Harvey Engineering Co., Ld. 22
Harvey, G. A. & Co. (Lond.) 143
Harvey, G. & A., Ltd. ..105
Hatch, Geo., Ltd. 57
Hawthorn, R. & W., Leslie and Co., Ltd. 10
Hayes, Edward ..4
Hayward-Tyler & Co., Ltd. 121
Head, Wrightson & Co., Ltd. 1
Heap, Joshua, & Co., Ltd... 86
Heavy Stampings, Ltd. ..6
Heenan & Froude, Ltd. ..39
Henderson, J. M., & Co. ... 1
Hendry, James, Ltd... 23
Herbert, R. G., Ltd. 77
Herbert Frood Co., Ltd. ..76
Heywood, S. H., & Co., Ltd. 1
Hick, Hargreaves & Co., Ld. 48
Hindley, K. S., & Sons 104&125
Hinzley, R., & Sons, Ltd. ..104
Hobdell, Way & Co., Ltd. ..27
Hoffmann Mfg. Co., Ltd... ..29
Holden & Brooks, Ltd. ..141
Holderworth & Sons, Ltd. ..128
Hollings & Guest, Ltd. 9
Holt & Willetts ..135
Hope, Henry, & Son, Ltd. ..86
Hordern & Mason ..15
Houston, J. W. & Co. ..100
Howard Prest. Eng. Co., Ltd. ... .134
Howden, James, & Co., Ltd. ..37
Hudswell, Clarke & Co., Ld. 136
Hull Gen. Pat. & Eng. Wks. 148
Humble Engine Co., Ltd. ..135
Hunt & Mitton, Ltd. 143
Hurst, Nelson & Co., Ltd. ... 1
Hyatt Ltd. ... .146
Ignasic Electric Co., Ltd. ..16
Imperial Eng. Service ..149
India-Rubber, Gutta-Percha and Telegraph Works Co. 146
Ingersoll-Rand Co. 45
Ironite Co., Ltd. 98
Jack, Alexander & Co. ..92
Jeffrey Manufacturing Co. 98
Jenkins, R., & Co. 142
Jennings, E. J. 1
John, T. G., Ltd. 128
Johnson & Phillips, Ltd... 129
Jones & Lamson Machine Co. 127
Jones & Shipman, Ltd. ... 77
Jopling, E. & Sons, Ltd... 102
Kearns, H. W., & Co., Ltd. 100
Keith, J. & Blackman Co. 127
Kelvin, Bottomley & Baird, 110
Kennedy's (Carntyne) Ltd. 109
Kilmarnock Wor'ks & Saunders 140
Kenyon, Alexander, & Co. 105
Kenyon, Wm., & Sons, Ltd. 106
Kirkstall Forge Co., Ltd. 130
Lancashire Dynamo and Motor Co., Ltd. 96
Lancaster & Tonge, Ltd ... 11
Lang, J., & Sons ... .46
Laurence, Scott & Co., Ltd. 90
Lea Recorder Co., Ltd. ..143
Leathers Co. (Altrincham) 134
Le Bas, Edward, & Co. ..23
Lee, Arthur, & Sons, Ltd. 92
Leeds Forge Co., Ltd. ... 126
Leroy, F., & Co. ... .144
Lidgerwood Mfg. Co. 138
Lilleshall Co., Ltd. 97
Lindsay, R. B., & Co. ... 105
Lipscombe, F., & Co. 143
Liverpool Refrig. Co., Ltd. 138
Lloyd, F. H., & Co., Ltd. ..96
Lloyds Bank Ltd. 113
Lobnitz & Co., Ltd. 109
Lodge Plugs Ltd. 102
Lofts & Spencer, Ltd. ..140
Lyon, Arthur & Wrench ..144
McClintic-Marshall Products Co. ... .31
McGowan, Wild, & Co. ... 4
McKenzie & Holland, Ltd 23
McKie & Baxter 95
McRobie, John, & Sons ... 4
McNeil, Charles, Ltd. ..149
MacLellan, P. & W., Ltd... 1
Maiden & Co., Ltd. 10
Manning, Wardle & Co., Ltd. 127
Markt & Co. (London) ... 6
Marsden, H. R., Ltd. ... 78
Marsden, S., & Son, Ltd. ..98
Marshall, Sons & Co., Ld. 43&110
Massey, B. & S., Ltd. ... 1
Mandsley Motor Co., Ltd. 146
Mavor & Coulson, Ltd. ..141
Maxwell & Fage 113
Mead, Henry, & Co., Ltd. 149
Meaf Consulting Service ..142
Meldrums, Ltd. 142
Merrywether & Sons, Ltd. 111
Metallic Valve Co. 112
Metallurgical Co., Ltd. ..118
Metropolitan-Vickers Electrical Co., Ltd... 79
Middleton, Robt. & Co. ..110
Midland Press work Co. ..79
Midland Railway Carriage and Wagon Co., Ltd. ..130
Milton Ltd. ... .140
Mills, William, Ltd. 96
Mild Steel Castings, Ltd... 90
Mirrlees, Watson Co., Ltd. 129
Moorlands Engineering Co. 21
Morton & Weaver ..106
Motor Rail & Tram Co. Ltd. 120
Mumford, A. G., Ltd. ... 1
Munzing, H., Ltd. 129
Musgrave Bros. 4
Napier Bros., Ltd. 82
National Boiler & General Insurance Co. 144
National Gas Engine Co., Ld. 41
Newall Engineering Co. ... 1
Newalls Insulation Co. ..140
Newbold, Walter & Co. ... 22
Newton, Bean & Mitchell ... 7
Nichols Pump & Eng. Co ... 143
Nicholson, W. T., & Clipper Co., Ltd. 98
Niles-Bement-Pond Co. ... 42
N. E. Marine Eng. Co., Ltd. 21
N. European Eng. Co., Ltd. 139
Normand, Augustin 1
Notcutt, Walter P., Ld. ... 18
Oakey, J., & Sons, Ltd. ... 144
Ohio Blower Co. ... .17
Oriental Tube Co., Ltd. ..106
Osborn, Samuel, & Co. Ltd. 34
Oxy-Acetylene W'ding Co. 92
Painters Ltd. 119
Paro., Ltd. 10
Parker, J. E. 1
Parkinson, J. & Son, ...140
Peebles, C. & Co., Ltd. ..102
Partington Steel & Iron Co. 44
Patent Die-Casting Co., Ltd. ... .121
Paterson Engineering Co. 143
Paul, Matthew, & Co., Ld. ... 1
Peckett & Sons, Ltd. 138
Penman & Co., Ltd. 105
Perkins, Ltd. 145
Picketts Ltd. 109
Pickles, John, & Co. 107
Piggott, Thos., & Co., Ltd. 128
Plenty & Son, Ltd. 11
Pollock & Macnab, Ltd. ..106
Pontifex & Wood, Ltd. ... 139
Popes Electric Lamp Co. ... 69
Pott, Cassels & Williamson 99
Powerite Steam Jointing Co. 107
Pratchitt Bros. ... .140
Precision Gauges, Ltd. ... 146
Premier Cooler & Eng. Co. Ld. 110
Priestman Bros., Ltd. ... 124
Principe & Co. 1
Projectile & Eng. Co., Ltd. 14
Purdon, Chas., Ltd. 67
Rahn-Larmon Co. ... .146
Ramshay & Marshall, Ltd. 103
Ransome & Mehr Mach. Co. 17
Ransomes, Sims & Jefferies 99
Reay Gear Works, Ltd. ..128
Reddaway, F., & Co., Ltd. 127
Redman, C., & Sons 86
Redpath, Brown & Co., Ld. 80
Reid Gear Co. 142
Rendle, Blanchard, & Co. ... 23
Reyrolle, A., & Co., Ltd. ... 143
Rice & Co. (Leeds), Ltd. ..146
Richardsons, Westgarth & Co. 10
Robertson, Thos. B. 81
Rose, Downs & Thompson 139
Ross & Duncan 8
Rowan, David, & Co. 142
Rowes & Co. 107
Royce Limited ... ... 1 & 32
Ruston & Hornsby, Ltd. ... 21
Rudge-Whitworth, Ltd. ... 68
Russell, G., & Co., Ltd. ... 1
Russell, John G. 10
Russell, John, & Co., Ld. ... 15
Russell, John & Co. (Walsall) Ltd. ..110
Sankey, J. & Sons, Ld. 115 & 142
Savery, T. A., & Co., Ltd... 93
Schneider & Cie 96
Scott, David 106
Scottish Stamping and Eng. Co. 143
Scottish Tube Co., Ltd. 1 & 101
Seagers, Ltd. 16
Selson Engineering Co. 59 & 113
Shanks, Thomas, & Co. ... 140
Shaw, John, & Sons (Wol.) Ltd. 119
Shore, Thos. & Sons, Ltd. 142
Showell, E., & Sons, Ltd. ..107
Shuster, F. B. Co. 109
Simons, Wm., & Co., Ltd. ... 7
Sleeper & Hartley, Ins. ... 116
Smedley Bros., Ltd. 143
Smethwick Stamping Co. ..124
Smith, Barker, Willson and Co. ... ... 92 & 140
Smith Bros. & Hill, Ltd. ..143
Smith, E. J. & Co. 141
Smith & Grace, Ltd. 97
Smith, S. & Son 122
Smith, Sydney, & Sons ... 139
Smith, T. Alkens (Rodley) Ltd. 129
Societe Genevoise 30
Soc. M. M. T., Ltd. 33
Smulders, J. F. 84
Somers, Walter & Co., Ltd. 36
Somerville, D. G. & Co., Ld. 9
Southern, J. W., & Son, Ltd. 10
Spafford Tool Works 107
Spencer, John, Ltd. 143
Spencer, W. H. & Co. ... 1
Standard Eng. Co. 141
Standard Pickon Ring and Eng. Co., Ltd. 145
Steam Cyl. Lubricator Co. 16
Steel Co. of Scotland, Ltd. 19
Steel Pipe Co., Ltd. 141
Steinle Turret Machine Co. 84
Stephenson, R., & Co., Ltd. 135
Sterling Metals, Ltd. 30
Sterne Ltd. ... ... 121 & 123
Steven & Struthers 6
Stewarts & Lloyds, Ltd. 1 & 28
Stoker, A., & Co. ... .131
Stone, J., & Co., Ltd. 143
Stothert & Pitt, Ltd. 18
Stringer, Bros. 4
Stuertevant Eng. Co., Ltd. 145
Sugden, T., Ltd. ... .112
Summers & Payne, Ltd. ... 146
Summerson, T., & Sons, Ltd. 1
Sun Shipbuilding Co. 94
Sutcliffe Brothers 4
Swift, George, & Sons, Ltd. 142
Tangyes Limited 49
Taylor & Challen, Ltd. 1
Taylor, Chas. (Birmingham), 50
Telephone Mfg. Co., Ltd. ... 67
Terry Steam Turbine Co. ..118
Thermostank Co. 8
Thomas & Bishop ... .143
Thompson, John (Wol.) Ltd. 141
Thornycroft, J. I. & Co. ... 47
Tilghman's Pat. S. Blast Co. 70
Tinsmith & Wright Machine Tool & Eng. Co., Ltd. ..146
Tomey, Joseph, & Sons, Ltd. 141
Tranter, W. J., Ltd. 106
Trevenet, F. J., & Procter, Ltd. 1
Trier Bros., Ltd. 30
Triplex Safety Glass Co., Ltd. 4
Triumph Stoker, Ltd. ... 110
Tubes, Limited ... ... 1 & 121
Tubi-Togni Ltd. 61
Tumbull, A., & Co., Ltd. ... 12
Tullis, D. & J., Ltd. 140
Tullis, J., & Son, Ltd. 96
Turton, T., & Sons, Ltd. ... 110
United Metal Engraving Co. 96
United States Metallic Packing Co., Ltd. 99
Variable Speed Gear Co., Ltd. 98
Vaughan Crane Co., Ltd. ..145
Vickers, S. R., Eng. Co. 141
Vickers Limited ... 72, 74 & 75
Vickers-Petters Ltd. 59
Vosper & Co., Ltd. ... 1 & 6
Wakefield, C. C., & Co., Ld. 18
Walker, W. A., & Co. 18
Walker Bros. (Wigan), Ltd. 18
Walker, James & Co., Ltd. 19
Walker, Wm., & Sons, Ld. 120
Wallsend Slipway & Eng. Co. 84
Wallworth, H., & Co., Ld. ... 4
Ward, H. W., & Co. 143
Ward, Hagans & Smith ... 89
Watson, Laidlaw & Co., Ltd. 145
Watson, Stanley J. 104
Watson, T. H. 107
Waygood Otis, Ltd. 111
Webster & Bennett, Ltd. ... 25
Weir, G. & J., Ltd. ...79 & 119
Weldless Steel Tube Co. Ltd. 140
Wells, A. C., & Co. 91
Werf Conrad 62
Western Wheeled Scraper Co. 96
Westinghouse Brake Co., Ltd. 125
Westwood, J., & Co., Ltd. 140
Wheeler Con. & Eng. Co. ..108
Whitaker, D. 1
White, F. E. & Co. 134
White, Rd., & Sons 142
White's Injectors Ltd. ..134
Wiggins, F., & Sons 110
Wigglesworth, F., & Co. ..104
Wilkin, Tudor, A. 11
Wilson, J. H., & Co., Ld. ... 1
Wilson, W. Martin & Co. 13
Wimcott, G. F., Ltd. 143
Wisconsin Electric Co. ..109
Wonham, Bates & Goode ..97
Wood, Hugh, & Co., Ltd. ... 92
Worthington Simpson, Ltd. 49
Yarrow & Co., Ltd. ... 1 & 87
Yorkshire Copper Wks. Ld. 6
Zenith-Carburetter Co., Ld. 91

ROSS & DUNCAN.

MARINE ENGINEERS & BOILERMAKERS, 6700

WHITEFIELD WORKS, GOVAN, GLASGOW.

ADMIRALTY CONTRACTORS.

TELEGRAMS: "WHITEFIELD, GLASGOW."

THE YORKSHIRE COPPER WORKS LTD.

Have Supplied Tubes for the following Dreadnoughts, viz.:—

LEEDS.

CODES:—"A.B.C." (4th and 5th Editions), Liebers, Scott, Western Union, Marconi International.

"Queen Mary," "Audacious," "Princess Royal," "Lion," "Monarch," "King George V," "Thunderer" "Orion," "Centurion," "Conqueror," "Benbow," "New Zealand," "Iron Duke," "Marlborough," "Tiger," "Delhi," "Queen Elizabeth," "Warspite," "Valiant."

COPPER, BRASS, **TUBES** CONDENSER TUBES.

6423

SOLE MAKERS OF **"BEMAL"** BRASS CONDENSER TUBES.

CONVEYOR AND ELEVATOR Co

J. J. Stevenson, Proprietor.

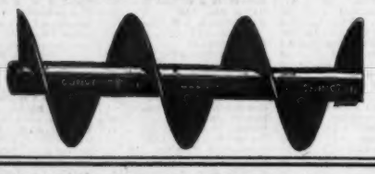
BULL BRIDGE WORKS,
Accrington, Lancashire.

CONTRACTORS TO H.M. GOVERNMENT.

SPIRAL CONVEYORS.
COAL CONVEYORS.
GRAIN CONVEYORS.
TRAY CONVEYORS.

STOKEHOLD CONVEYORS.
GRAIN ELEVATORS.
COAL ELEVATORS.

CHAIN ELEVATORS.
BELT ELEVATORS.
BALE ELEVATORS.



8126

Telegrams: "Conveyor, Accrington."

National Telephone No. 2779.

Telegrams— "REPSOV, PORTSMOUTH."

VOSPER & CO., LTD.,
PORTSMOUTH.

Telephones— 2137 and 2138.

ESTABLISHED OVER FIFTY YEARS.

ENGINEERS AND SHIPBUILDERS.

REPAIRS OF ALL KINDS.

We can quote for SMALL VESSELS, YACHTS, TUGS, BARGES, STEAM and MOTOR LAUNCHES.

Various Sizes of STEAM ENGINES and BOILERS being built. *REASONABLE PRICE AND QUICK DELIVERY.*

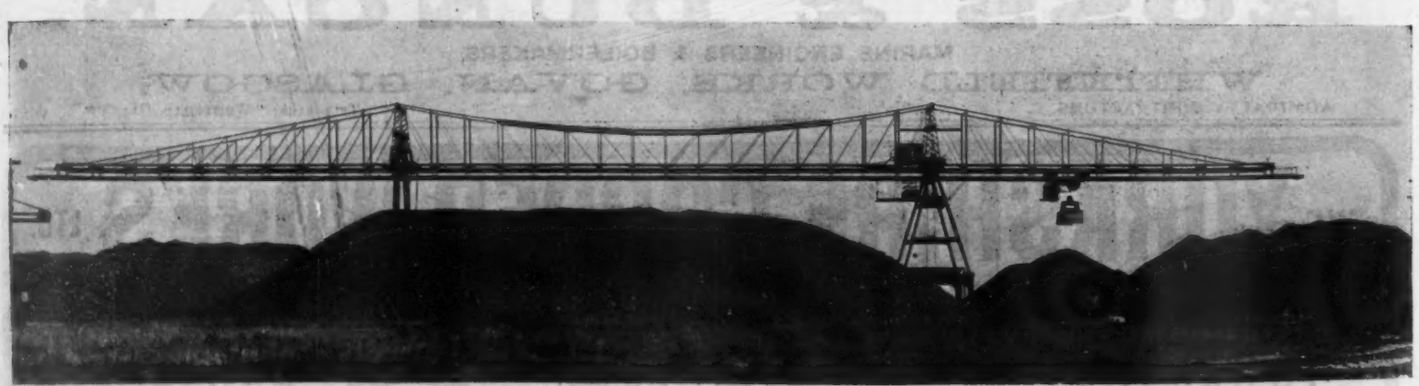
ECONOMY IN CONSTRUCTIONAL COSTS

can be obtained by using GOOD Malleable Iron Fittings—there are none better than—

"D" BRAND MALLEABLE TUBE FITTINGS

PERFECT CASTINGS—ACCURATE THREADS—GOOD FINISH. 8095

INSIST ON "D" BRAND—Your Factor can Supply them from Stock, if not, Write to—**MARKT & Co. (London), Ld., 98/100, Clerkenwell Rd., London E.C 1.**



Brownhoist Coal Handling Bridge at the Plant of the Astoria Light, Heat and Power Company, Astoria, New York. The bridge is equipped with a 330 cu. ft. Brownhoist Bucket which handles 8 tons of coal at a grab.

BROWNHOIST

Write for Catalogues.

Brownhoist Bridges, Locomotive Cranes and Ore and Coal Handling Machinery are used throughout the World. And Brownhoist quality, gained through 40 years' crane building and engineering experience, is the best possible guarantee to the proper solution of your handling problem. Write us when you wish information.

2021

The Brown Hoisting Machinery Company

40 years in Crane Business

Engineers and Manufacturers of Heavy Dock Machinery, Bridge Cranes, etc., as well as smaller Cranes and Hoists.

Cable Address: "Brownhoist,"

Cleveland, Ohio, U. S. A.

European Representative: H. E. Hayes, 12, Rue de Phalsbourg, Paris.

Telegraphic Addresses:—
"SIMONS, RENFREW."
"SIMONISM, LONDON."

"SIMONS"

Codes:—
A B C (5th Edition).
SCOTT'S (10th Edition).
BENTLEY'S.

Marine Dredge Plant

OF ALL DESCRIPTIONS AND UP TO THE HIGHEST CAPACITY.

Constructors of
HOPPER AND BARGE-LOADING BUCKET DREDGERS,
BARGE-LOADING, RECLAMATION & "SIMONS" CUTTER SUCTION DREDGERS.

Proprietors of
ALFRED WATKINS' BRITISH PATENT for ROTARY SPUDS.

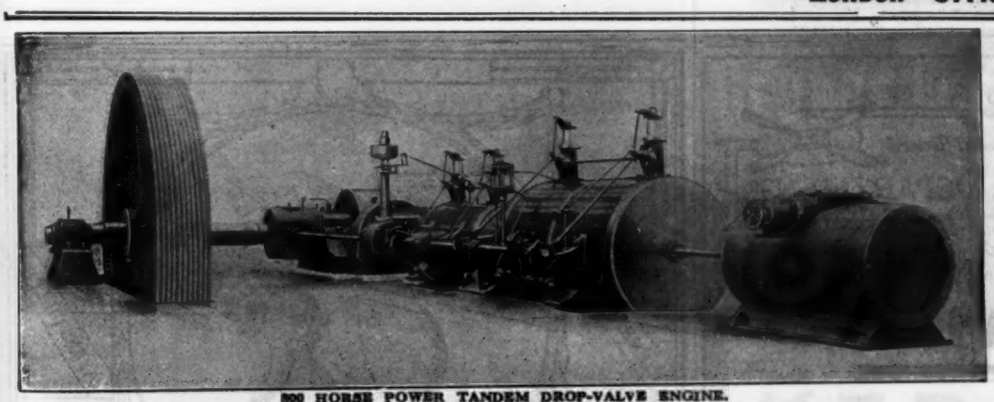
PATENT
CUTTER
HOPPER

TRAILING SUCTION HOPPER DREDGERS.
GOLD AND TIN RECOVERY DREDGERS.
HOPPER BARGES.
FERRY STEAMERS.
REPLACE PARTS for EXISTING DREDGERS.

INVENTORS AND FIRST CONSTRUCTORS OF "HOPPER" DREDGERS AND ELEVATING DECK FERRY STEAMERS.

WM. SIMONS and CO., LTD. **DREDGERS** **· RENFREW · near GLASGOW.**

LONDON OFFICE: 83, VICTORIA ST., S.W.



800 HORSE POWER TANDEM DROP-VALVE ENGINE.

NEWTON, BEAN & MITCHELL,

Engine Builders and Millwrights,
DUDLEY HILL, BRADFORD.
Telegrams: "ADROIT, DUDLEY HILL."
'Phone: 125 DUDLEY HILL (3 lines).

STANDARDISED MANUFACTURES
TANDEM, CROSS COMPOUND, and VERTICAL ENGINES.
All with our Improved Piston Drop Valves.
CONDENSING PLANT.
TRANSMISSION MACHINERY
Of all kinds.
ENGINES INDICATED & DETAILED
REPORTS PREPARED.

We invite enquiries and correspondence, which shall have our best attention at all times.

HAM, BAKER & CO., Limited,

CARRY LARGE STOCKS

READY FOR IMMEDIATE DELIVERY
OF
SLUICE, REFLUX and AIR VALVES,
HYDRANTS, SURFACE BOXES, PENSTOCKS, &c.

Address—
HAM, BAKER & CO., Limited, *Engineers, Iron & Brass Founders,*
Telegrams—
PENSTOCK, LANGLEY, WORCS.
Langley Green, BIRMINGHAM.
Telephone—
87 OLDBURY.

CAMMISS "NUT-LOCK" WASHER
IS RELIABLE.

Single Nut and Bolt securely held.

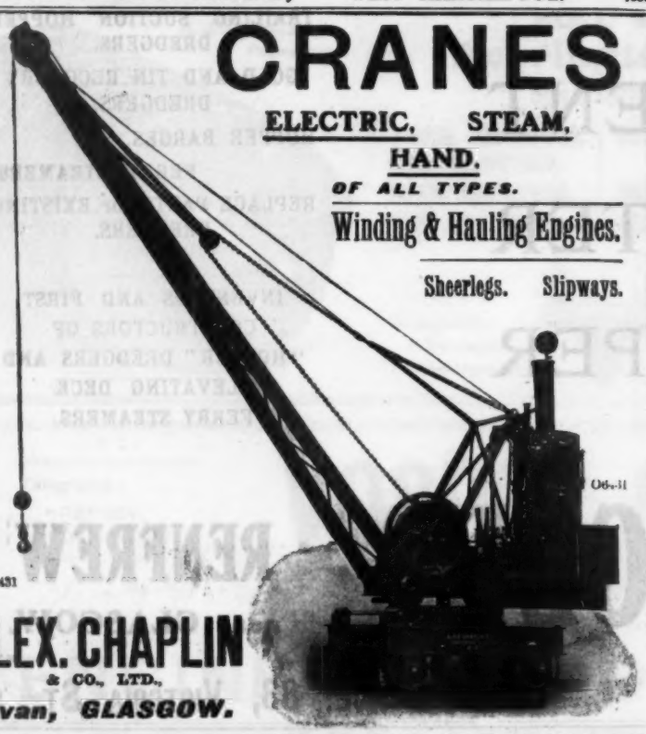
Send for Sample Washer.

E. E. CAMMISS, 160, Alma Street, WEST HARTLEPOOL. 9886

CRANES
ELECTRIC, STEAM, HAND.
OF ALL TYPES.

Winding & Hauling Engines.

Sheerlegs. Slipways.



Od. 6431

ALEX. CHAPLIN
& CO., LTD.,
Govan, GLASGOW.

BRADLEY & COMPANY, LTD

TELEPHONE: BILSTON 161 2 LINES. **BILSTON.** TELEGRAMS: GALVANIC BILSTON

SPECIALISTS IN SHEET METAL PRESSINGS & STAMPINGS
OF EVERY DESCRIPTION IN STEEL, IRON, COPPER & BRASS
FOR ENGINEERING, MOTOR & ALLIED TRADES.
IRON PLATE & SHEET METAL WORKERS.

ART METALWORK IN COPPER & BRASS

HOLLOWWARE GALVANIZED TINNED & JAPANNED.

TRADE MARK "BELDRAY"

G R

By direction of the Disposal Board

AIRCRAFT DISPOSAL DEPARTMENT

MINISTRY OF MUNITIONS.

FOR SALE.

Sunbeam "Arab" AERO ENGINES
FOR USE AS STATIONARY ENGINES

The above Engines can be run on Town or Producer Gas, Paraffin, or Petrol.

They would be especially useful for Peak Load, occupying an extremely limited space, and are simple and easily maintained.

All information regarding Technical Data, and Permits to View a Working Installation, can be obtained from THE CONTROLLER, AIRCRAFT DISPOSAL DEPARTMENT, WELCOME CLUB, EARL'S COURT, (Nearest Station—West Kensington—District).

Telephone—Western 4950.
Telegrams—"Clearhouse, Aerosupply, London."

NOTE.—For particulars of other Government Property for Sale, see *SURPLUS*, price 3d., at all Bookstalls; or by Quarterly subscription of 2/-, post free, payable in advance, to the DIRECTOR OF PUBLICITY, Ministry of Munitions, Whitehall Place, London, S.W.1. C 358

7927

—And it remains a Permanent Protection from all Destructive Elements.

THIS recommendation of EVERITE and ASBESTILITE Roofing and Building Materials carries special weight with Engineering and Colliery Owners. Only materials of the greatest permanency can be used in cases of exposure to so many destructive agencies. EVERITE and ASBESTILITE are the most natural materials with which to construct Acid Houses, Boiler Houses, Blacksmiths' Shops, Coal Bunkers, Cooling Towers, Dock Sheds, Engine Houses, Elevators, Electric Shops, Forges, Foundries, Generating Stations, Laboratories, Loco Houses, Machine Shops, Offices, Pumping Stations, Power Houses, Storages, Warehouses etc., etc. In fact, there is no construction where EVERITE and ASBESTILITE cannot serve.

Our Laboratories and Engineering Works for experiment and research ensure a uniformly high grade product of unexcelled merit. Write for particulars.

BRITISH MADE **EVERITE & ASBESTILITE**
ASBESTOS-CEMENT BUILDING MATERIALS
CORRUGATED SHEETS—FLAT SHEETS—SLATES—TILES
FOR ALL BUILDING PURPOSES

OBTAIN A SAMPLE OF EVERITE and convince yourselves that it is not merely waved but scientifically corrugated to a great depth. The whole strength of the sheet lies in its depth of corrugation, and in this respect EVERITE is pre-eminent.

Unrestricted supplies available for Home and Export.

Illustrated Catalogues, Quotations, Samples, and full particulars from Sole Manufacturers:

BRITISH EVERITE & ASBESTILITE WORKS Ltd.,
29, PETER STREET, MANCHESTER, England.
Phone: 7790 MANCHESTER. Cables: "EVERITE, Manchester"—All Codes.

HYDRAULIC

ARMATURE PRESS

SPECIALLY MADE FOR PRESSING ARMATURES ON TO SHAFTS ALSO SMALL WHEELS AND SIMILAR WORK.

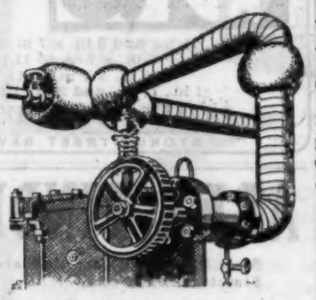
USEFUL TO ELECTRICAL ENGINEERS.

THE PRESS IS FITTED WITH AN ADJUSTABLE HEAD, WITH OPEN SLOT, THROUGH WHICH THE SHAFTS CAN PROJECT.

HOLLINGS & GUEST, Ltd.,
Thimble Mill Lane, Birmingham.

7865

FUEL ECONOMY.



Pluto Rope Pipe Covering.

Hear what an expert says.

• • • • •

Professor W. A. BONE, at a meeting of the Iron & Steel Institute said:

"MUCH yet remains to be done before British Iron and Steel Works attain anything like the practical ideal of fuel economy. So far as I can see, fuel costs will be the biggest item in Iron and Steel production. The problem of fuel economy is one rather of scientific organisation and co-ordination, than of the discovery of new principles. In all the larger works there ought to be an organised staff wholly engaged under competent direction in controlling fuel consumption."

THE first step towards reducing fuel costs is to insulate all uncovered pipes and flanges with Pluto Blue Asbestos. For Blue Pluto Rope Pipe Covering is showing its remarkable insulative and fuel saving properties in hundreds of large factories throughout the country.

Let us send you data which will show exactly how much you annually lose by having uncovered pipes. We will also enclose Government Test Reports which leave no doubt as to the most efficient insulators.

The Cape Asbestos Co Limited
Guildhall Annexe · 23 King Street · London E.C
Factory, Barking, Essex

7863

Portion of Tannery.

THE Expansion Period.

The period of expansion is definitely here. Factories, Warehouses, Public Institutions, Dwelling Houses, &c., will shortly be springing up everywhere, and Railways, Roads and Public Works will be expanding on a scale hitherto unheard of in order to cope with the coming inflow of world trade.

The tide is commencing to flow. Be ready. You cannot afford to waste valuable months, perhaps years, constructing your new buildings, extensions, or works by old-fashioned methods. The name of Somerville signifies speed in construction and erection, efficiency in materials and men.

Steelwork and ferro-concrete are the efficient building materials of the future.

We shall be glad to quote for any kind of Building or Public Works Construction. Advice gladly given.

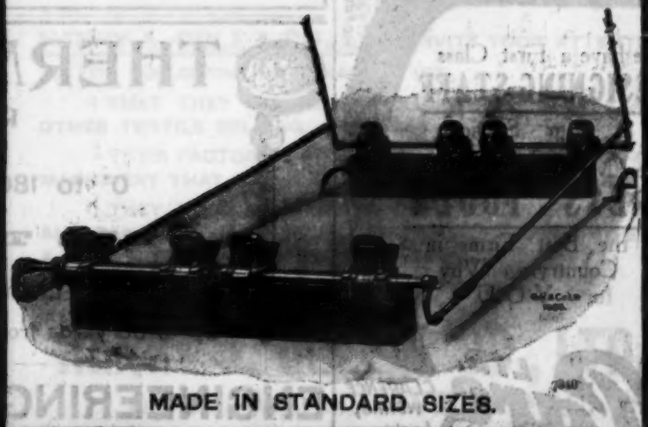
7869

D. G. SOMERVILLE & CO., Ltd.,
120-122, Victoria St., Westminster, S.W.1. Works: New Cross, S.E.

GEORGE FLETCHER & Co. LTD.
DERBY.

SPECIALISTS IN
COLLIERY, MINING AND CEMENT WORKS PLANT.

"AMARILLA" PATENT
KEP GEAR



MADE IN STANDARD SIZES.

Send us your Enquiries.

STONE AND COAL CRUSHERS
ENG.
LEICESTER
GOODWIN BARSBY & Co

THE
CLEVELAND BRIDGE AND ENGINEERING CO., LTD. 7669
Specialists in the Design, Manufacture, and Erection of Bridges, Girders, Roofs, Warehouses, and all Classes of Iron and Steel Constructional Work.
HEAD OFFICE AND WORKS—
DARLINGTON.

7798

Hindley Vertical Multitubular BOILERS
Satisfaction — and a - - - small fuel bill.
WRITE
E. S. HINDLEY AND SONS,
11, Queen Victoria - - Street, - -
LONDON, E.C.4
'PHONE: 9804 CITY.

Let US make those JIGS

You want JIGS to get PRODUCTION!
We have a First Class DESIGNING STAFF at your Service.
We Make . . . PRESS TOOLS for the Best Firms in the Country. Why not for YOU?
7683
LTD. Pars JIGS & TOOLS
CLARENCE WORKS, Lockhurst Lane, COVENTRY.

S & S
We have got
PINE
in Stock for Immediate Delivery, as follows:—
1 in., 1¼ in., and 2 in. x 7 in. and up, Best Quality, PINE SIDINGS.
3 in. x 7 in. to 11 in., Seconds, PINE DEALS.
3 in. x 7 in. to 11 in., Thirds, PINE DEALS.
1 in., 1¼ in., and 2 in., Unsorted Quality, PINE SIDINGS.
JAMES W. SOUTHERN & SON, Ltd.,
STORE STREET SAW MILLS, MANCHESTER. 7933

ALEX. FINDLAY & CO., Ltd.,
Steel Roof and Bridge Builders, Structural Engineers, ... MOTHERWELL, N.B.
Contractors for all the Main Buildings for the FRANCO-BRITISH EXHIBITION, LONDON, 1908, covering a total area of 560,000 square feet; also for the Grand Stadium, area 200,000 square feet. 9262
ALL KINDS OF STEEL STRUCTURES DESIGNED AND EXECUTED.
SPECIALITY:—HYDRAULIC PRESSED STEEL TROUGH FLOORING FOR BRIDGES AND BUILDINGS
Head Office . . . . . MOTHERWELL, N.B.
London Office . . . . . 9, VICTORIA STREET, S.W.
TELEGRAMS: FINDLAY, MOTHERWELL, PARKENHUK, LONDON

Sight Feed Lubricators
Sole Makers of 8081
Adams Patent Seafield Mechanical Lubricator and Grandison's Piston Type Lubricator.
STEAM KETTLES
for Canteens Ships, etc.
The Steam Cylinder Lubricator Co. Ltd
Gordon Works, Lr. Broughton :: MANCHESTER.

THE MIDLAND PRESSWORK CO.,
— DEPT. E., COVENTRY. —
6559
PRESSINGS IN ALL METALS.

THERMOMETERS
RECORDING.
0° to 1800° Fah.
ALL TYPES.
CAPILLARY TUBING,
Up to 50 yards from Source of Heat.

ENGINEERING SUPPLIES, LTD.,
SUFFOLK HOUSE, 5, Laurence Pountney Hill, E.C. 4.
Telegrams: "PROBLIS, LONDON." 7735 Telephone: CITY 9630

"RUSSELL" STEEL DOG SPIKES
For high-class quality and practical utility are unsurpassed. 7684
SOLE MAKER: JOHN G. RUSSELL, Clydesdale Nail Works, WISHAW, SCOTLAND.

ELECTRIC CONTROL LTD.,
Bridgeton, GLASGOW.
"Empire" Automatic Controllers.
See Display Advt., page 10, Dec. 12. 6603

Maiden & Co., Ltd., Machine Tool Makers, HYDE, Cheshire
See 1-page Advt. last issue. 6519

TURBO-PUMPS
for High and Low Pressures. 7580
Complete Hydr. Installations, Water Turbines, Pipe Lines, Zoelly Steam Turbines
ESCHER WYSS & CO., S.A., Engineers,
37/19 109, Victoria St., Westminster, S.W.

EVAPORATORS. 7309
Richardsons, Westgarth & Co. Ltd.
HARTLEPOOL, MIDDLESBROUGH & SUNDERLAND.
See Large Advertisement Nov. 14.

STEAM ENGINES
DIESEL ENGINES
CONDENSING PLANTS
POWER INSTALLATIONS
Cole, Marchent, & Morley, Ltd. Bradford, Yorks.
Displayed advt., Dec. 12, p. 23.

THERMOTANK Co
Heating and Ventilating Engineers,
55, West Regent Street,
GLASGOW. 8022
See last and next weeks illustrated advertisement.

"BRITIC"
— 4,000,000 H.P. in Service. —
WATER TUBE BOILERS and MECHANICAL STOKERS.
(800,000 H.P. in Service.) 7696
The British Mechanical Boiler Co., Ltd., The Clock House, Arundel St., Strand, W.C. 2.

WIREWORK
FOR ALL PURPOSES.
A COUSLAND & SON
3 MITCHELL ST., GLASGOW.

SYDNEY SMITH & SONS
(Nottingham), Ltd. 7898
Basford Brass Works,
NOTTINGHAM.
Write for Catalogue illustrating great variety of
BOILER MOUNTINGS
For MARINE, STATIONARY and PORTABLE ENGINES and BOILERS.

IGRANIC ELECTRIC CO. LTD
Controlling Devices.
LONDON & BEDFORD.

CENTRIFUGAL PUMPS
DON ACCORD & HIGH SPEED ENGINES
SEE 1-PAGE ADVT IN LAST ISSUE.
DRYSDALE & Co LTD, YOKER, GLASGOW, W.

Telegrams:—PISTONS, MANCHESTER.

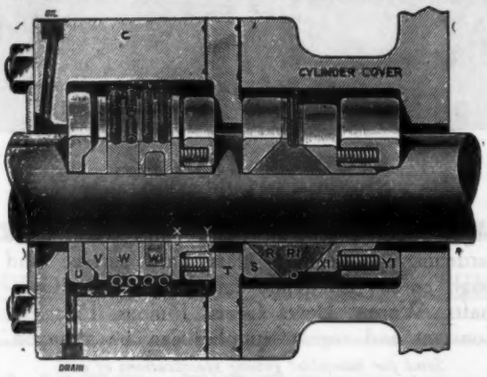
"The Lancaster" (R.T.M.)

Telephone No. 4621, Cent.

DOUBLE METALLIC

PACKINGS

FOR PISTON RODS AND VALVE SPINDLES.



FOR ALL PRESSURES, SPEEDS, AND SUPERHEATS.

Descriptive Circular Post Free on Application.

FIRST ORDERS ALWAYS "ON APPROVAL."

LANCASTER & TONGE, LTD.

Sole Makers of "The Lancaster" Steam Traps, Pistons, Limit Piston Rings, Steam Dryers, Machine Moulded Wheels, &c.

PENDLETON, MANCHESTER. 8036

Oil Engines

Established 1790 PLENTY BUILDERS OF MARINE OIL ENGINES

of Merit

THE EXPERIENCE BEHIND THE ENGINE WE BUILD—OVER 100 YEARS.

Knowledge of all the major and minor points of Marine Engine requirements is one of the greatest assets to the Engine Builder. Our experience in this direction dates back to the first introduction of Engines for marine use, whilst as a guarantee of workmanship and proved methods we point to our remarkable experience spread over the last hundred and twenty-nine years.

Have we your name on our free mailing list for a monthly copy of our useful Magazine, "OIL-POWER"? 8033

Established 1790.

PLENTY & SON LTD.

Contractors to The Admiralty, War, Indian & Colonial Offices, &c.

Telephone: 7 NEWBURY.

Telegrams: "PLENTY, NEWBURY."

Kings Road, Newbury, England.

WE ALSO SPECIALISE IN MARINE STEAM ENGINES.

Installations Periodically Inspected. Reported upon also Maintained by Arrangement.

Scale Formation Completely Overcome.

Specifications and Plans Prepared.

ANY DIFFICULTIES With Existing Installations ABSOLUTELY REMEDIED.

7780

Many years' experience in the following Systems—

LIME-SODA METHODS,

PERMUTIT PATENTED PROCESS

SAND FILTRATION,

Pressure and Gravity also

OIL ELIMINATION.

TUDOR A. Wilkin

Telephone: LONDON WALL 6721

Telegrams: CUERWARTER AVE LONDON.

15, New Broad St., LONDON, E.C.2.

95, St. Mary St., CARDIFF.

COLE'S BALATA BELTING

BALATA BELTING.

HENRY A. COLE & CO., LTD., INVITE YOUR ATTENTION TO THE FOLLOWING INFORMATION, VIZ.,

THAT THEY ARE MANUFACTURERS OF BALATA AND OTHER TEXTILE BELTING.

THEIR FACTORY IS FITTED UP WITH THE MOST PERFECT MACHINERY THAT SCIENCE AND EXPERIENCE CAN DEVISE.

THEY HOLD LARGE STOCKS OF ORDINARY WIDTHS, AND CAN MAKE ANY SPECIAL SIZE FROM 1" TO 50" WIDE AT A DAY'S NOTICE IF NECESSARY.

YOUR ENQUIRIES WILL BE ESTEEMED.

HENRY A. COLE & CO., LTD.,

Coronet Works, LIVERPOOL.

AND AT BEAUFORT ROAD WORKS, BIRKENHEAD. 7439

SIEMENS PROCESS
ESTD TRADE MARK 1872
"HALLSIDE"

CONTRACTORS TO—
BRITISH ADMIRALTY, WAR DEPT., and FOREIGN and COLONIAL GOVERNMENTS.

Manufacturers of—

MILD STEEL PLATES, ANGLES, Zed Bars, Tees and all forms of Sectional Bars required for Ship, Boiler, and Bridge Building, and other constructive purposes.

CASTINGS of all kinds and largest sizes for Ship Stems, Sterns, Posts, Anchors, Rudders, &c.

RAILS, BILLETS, FORGINGS.

AXLES of highest quality, to meet the requirements of Home and Colonial Railways.

TYRES.—Locomotive Carriage and Wagon, to all requirements.

SPECIAL STEEL of all kinds for constructive purposes.

THE . . .
STEEL COMPANY of SCOTLAND
LIMITED
23, ROYAL EXCHANGE SQUARE.
GLASGOW.

TELEGRAPH ADDRESS "STEEL" GLASGOW.

7318

Comet No. 2.
·15% Carbon Steel

forges and machines easily and after case hardening produces a glass hard surface and tough core. Eminently suited for Cams, Camshafts, Worms, Bevel Gears, Pinions, Pins, etc. Constant and regular supplies can be arranged.

Send for pamphlet giving specifications of our 15 leading grades of Carbon and Alloy Steels. 8144

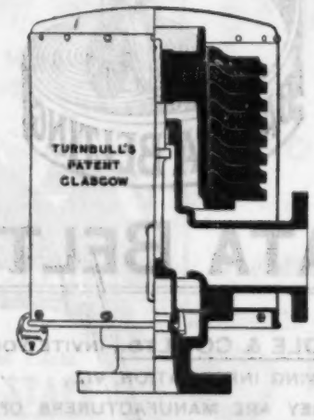
W. GILBERTSON & CO., LTD.,
6, Lancaster Place, Strand, London, W.C. 2.

Telephone: Gerrard 4365. Works: PONTARDAWE. Wires: "Gilmaximp" Rand, London.

COMET STEELS

VALVES
AND
BOILERMOUNTINGS

MAKERS OF ALL KINDS OF VALVES AND BOILER MOUNTINGS, STEAM TRAPS, STEERING GEARS, CAPSTANS, WINDLASSES, PUMPS, &c.



Dead Load Safety Valve with Lock-up Cover

UNEQUALLED FOR SIMPLICITY, RELIABILITY, EFFICIENCY, DISCHARGING CAPACITY.

AGENTS WANTED WHERE UN-REPRESENTED.

CORRES-PONDENCE INVITED.

APPROVED BY HOME AND FOREIGN GOVERNMENTS, BOARD OF TRADE, LLOYD'S, AND INSURANCE COMPANIES. 7052

ALWAYS SPECIFY
TURNBULLS
ALEX. TURNBULL & CO., Ltd., BISHOPBRIGGS, GLASGOW.
Telephone—49 & 50, Bishopbriggs. Telegrams—Valve, Glasgow.

Alldays

TOOLS
For ENGINEERS, &c.
Highest Quality.

"Octopus" Chain Pipe Wrenches
"Octopus" Pipe Cutter
Ratchet Braces
Taps, Dies and Reamers
Smiths' Tools, Tongs, &c.

Sole Makers—
ALLDAYS & ONIONS, Ltd., BIRMINGHAM,
Indian Agent—
Alfred Herbert, CALCUTTA, and at
Representative for India, excepting BOMBAY Presidency
58, Holborn Viaduct, LONDON.
7170

GALLOWAYS LTD.
MANCHESTER

Telephone —6812-3-4 CENTRAL

INCREASED HEATING SURFACE.

MODERN DESIGN.

LARGE COAL SAVING.

HIGHEST EFFICIENCY

GALLOWAY PATENT BOILER.

ENGINES : BOILERS
FOR
COLLIERIES, STEELWORKS, FACTORIES, PUMPING

ESTB 1907.

W. MARTIN WINN & Co.
STATION WORKS,
DARLASTON.

BRIGHT DRAWN STEEL BARS HEX, SQUARE, & ROUND.

BRIGHT STEEL BOLTS & NUTS, STUDS, SET PINS, ETC.

PHONE 73.

TELEGRAMS- "ACCURACY."

WALKER BROS. (WIGAN), LTD.
Codes:—A B C, 4th and 5th, Liebers, Moreing and Neal Mining Code, A1 Universal Mining, Western Union.
ESTABLISHED 1866.

AIR COMPRESSORS

A pair of Corliss Compound Steam Two-Stage Air Compressing Engines, with Valves to Walkers' Latest Pattern.

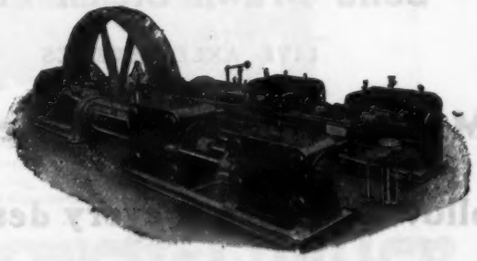
with Valves to recent Patents now at work (or on order) indicating over
150,000 HP.
Raising our total output during 40 years to
520,000 I.HP.
Patent Unloading Device for Power-driven Plants.

Winding, Hauling, and General Mining Machinery.

VENTILATING FANS

of the Walker "Indestructible" type.
Capacity of Fans at work or on order:
105,000,000
cubic feet per min.

HIGH MECHANICAL EFFICIENCY
whether driven by steam or electricity.



A pair of Four-cylinder Triple Expansion Driving Engines, with Corliss Valve Gear. 7481

Pagefield Ironworks, WIGAN.
Telegraphic Address: "Pagefield," Wigan. Telephone: No. 14 Wigan (3 lines).

Complete Gearing. *HIGH GRADE* Gear Cutting.
MACHINE TOOLS
for Railway, Engineering, Boiler Shop and Shipyard Plants.

WOOD WORKING MACHINERY.

BALING PRESSES AND CONCRETE BLOCK PRESSES.

"KEYSTONE" ALL STEEL PULLEYS.

REGISTERED TRADE MARK

HEAVY DUTY SAWING MACHINES.

W. A. WALBER & Co.
ENGINEERS,
38, Victoria St., Westminster, S.W.1.

Telegrams— "Vilvalle, London." 1973 Telephone— Victoria 2190 (2 lines).

Chemical Laboratory Glassware and Porcelain Resistance Glass, Soda and Lead Glass Tubing and Rod, Porcelain Combustion and Pyrometer Tubes, &c., &c.

Highest Grade of British Manufacture.

The above can be supplied by the

British Chemical Ware Manufacturers' Association, Limited,

who are the actual manufacturers. 1738

For your own protection note that each article bears the Trade Mark of the maker. For further particulars and prices, &c., apply to the Secretary, British Chemical Ware Manufacturers' Association, Limited, 51, Lincoln's Inn Fields, London, W.C. 2. Samples may be seen at the Offices of the Association.

FINDLAY'S SPECIAL MOTOR METAL.

The most reliable alloy on the market for bearings working under the severest conditions, such as bearings of Aero Engines, Motor Transport, Heavy Marine Engines, &c.

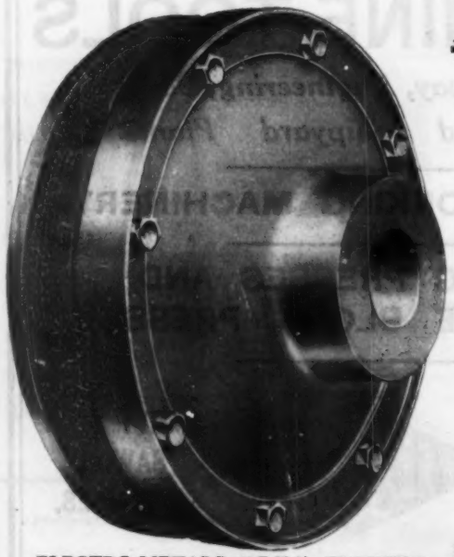
GLACIER METAL.

OUR STANDARD METAL FOR GENERAL ENGINEERING WORK.

Specially recommended for bearings of Electrical Machinery, Rolling Mill Plant, Stone Crushers, Colliery Repairs, Tramway Motors, &c.

Glacier Anti-Friction Metal Co., Ld.,
Waldo Road, 8378
WILLESDEN JUNCTION, LONDON, N.W. 10.

FLEXIBLE COUPLINGS.



ELECTRO-METALS "Z.V." FLEXIBLE SHAFT COUPLING. 7873

For all purposes, especially where exceptionally severe service is encountered.

All Couplings are well balanced, resilient, and reliable.

ELECTRO-METALS Ltd.,
Head Office: 56, Kingsway, London, W.C. 2.
Telephone: 6420 HOLBORN. Telegrams: "PROCESSES, 'PHONE, LONDON."
Works: STOKE-ON-TRENT, STAFFS.

GAS VESSELS.

Weldless Steel Gas Vessels
OF ALL DESCRIPTIONS.

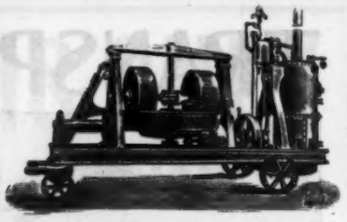
Air Reservoirs, Ammonia Flasks, Acetylene Flasks,
IN ALL SIZES AND CAPACITIES, BOTH ENGLISH AND METRICAL.

Solid Drawn Steam Pipes.

LIVE AXLE SLEEVES
AND
Motor Car Forgings a Speciality.

Hollow Forgings of every description

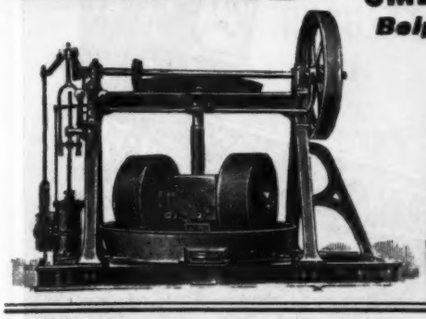
Address: 7720
THE PROJECTILE & ENGINEERING CO., LTD.,
New Road, Wandsworth Road, LONDON, S.W. 8.
Telegrams: "Profectus," London. Telephone: Brixton 2117, 2118, 2760.

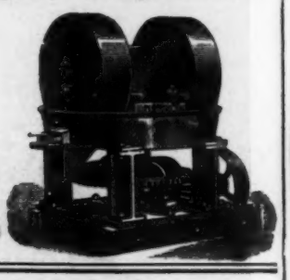


GRINDING MILLS.

SMEDLEY BROS., LTD.

Belper, Derbyshire. 7603





Capstan Work

IMMEDIATE DELIVERIES.

SEND US YOUR ENQUIRIES.

BRASS PARTS up to 2 in. diam.

MILD STEEL PARTS up to 1½ in. diam.

ORDNANCE FUSE MANUFACTURERS.

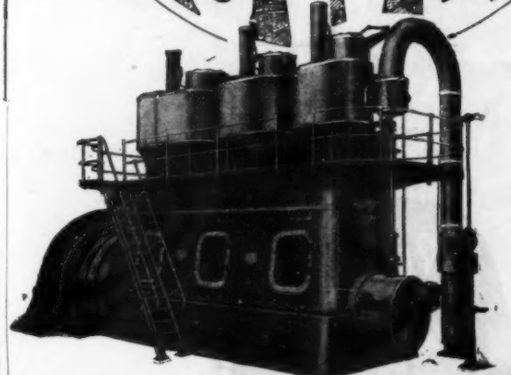
JOHN Russell & CO LTD

NEW SPRING STREET, BIRMINGHAM.

Phone 1401 CENTRAL. Telegrams: BELMONT, BIRMINGHAM

9081

BETTER DRIVING POWER



1500 HP. Triple Expansion Steam Engine Direct Coupled to Dynamo.

Better Driving Power invariably follows from the installation of Browett-Lindley Quick Revolution, Forced Lubrication Steam Engines. With Browett-Lindley Steam Engines you can rely on the constant, steady running of your plant and avoid the losses that result from stoppage of the power engine.

Browett-Lindley

Steam Engines.

6436

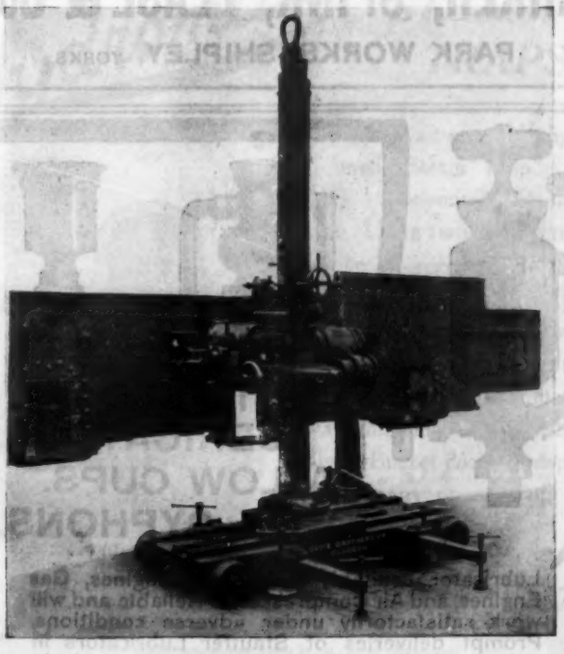
BROWETT, LINDLEY & Co., Ltd., Sandon Works, Patricroft, Manchester.

London Office: Amberley House, Norfolk St., Strand. Glasgow Office: "Bandon," Westerton, N.B.

MOTOR-DRIVEN "UNIVERSAL"

PORTABLE RADIAL DRILLING MACHINE

"An indispensable Machine for Locomotive Builders"



7789

DAVIE BROTHERS LTD. GLASGOW.

Wakefield Patent

MECHANICAL LUBRICATOR

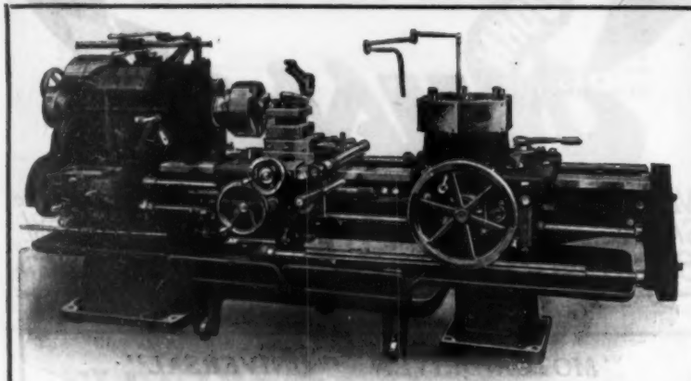
For **Saturated and Superheated Steam, Gas & Oil Engines, Air Compressors, &c.**

Nearly **22,000** ENGINES NOW FITTED WITH WAKEFIELD LUBRICATORS.

7815

C. C. WAKEFIELD & CO., Ltd.,

Wakefield House, Cheapside, London, E.C. 2.



9 in. COMBINATION TURRET LATHES.

BARKER, SPINK, LEASE & Coy.

PARK WORKS, SHIPLEY, YORKS. 6130

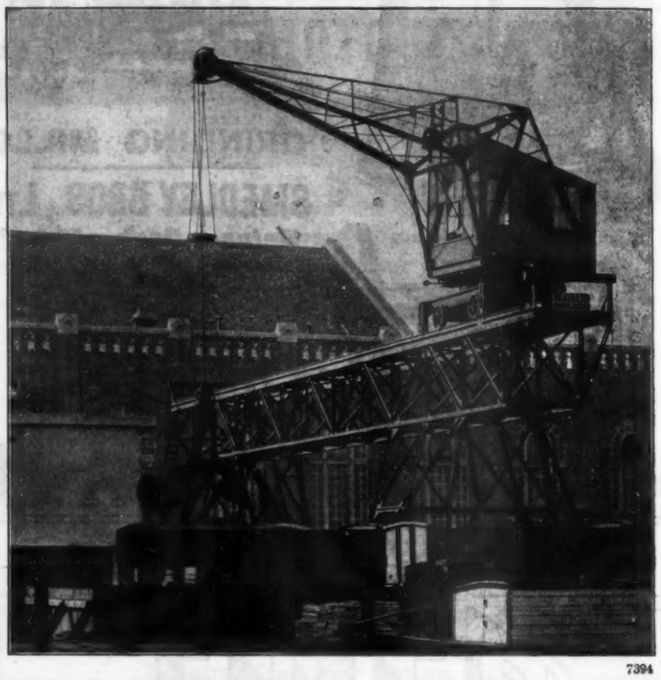
SIGHT FEED LUBRICATORS. TALLOW CUPS. OIL SYPHONS.

Lubricators suitable for Steam Engines, Gas Engines, and Air Compressors. Reliable and will work satisfactorily under adverse conditions. Prompt deliveries of Stauffer Lubricators in brass and iron, tallow cups, oil syphons, drain and testcocks, &c. Large variety in stock. 7809

BRITISH STEAM SPECIALTIES, LTD.

BEDFORD STREET, LEICESTER.

TRANSPORTERS



7394

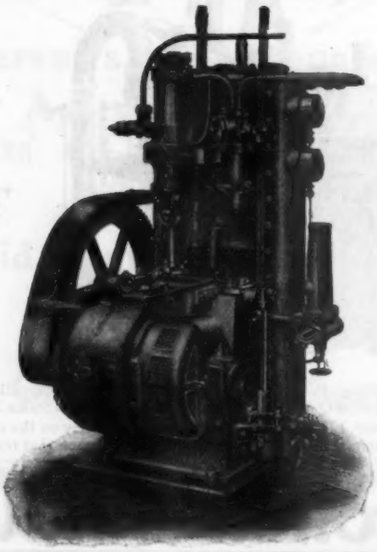
FIGEE LTD. HAARLEM HOLLAND

SOLE BRITISH AGENT: B·J·ALLISON

53, NEW BROAD STREET, LONDON, E.C. 2.

Tele: "Soundings, 'Phone, London." 'Phone: London Wall 1137. Code: A B C ((5th Edition).

CO_2 REFRIGERATING MACHINES NAVAL TYPE.



Telegrams: SEAGERS, DARTFORD.

National Telephone 26, DARTFORD.

SEAGERS, Ld.

DARTFORD. 8077

THERE IS ONLY
ONE MACHINE
(MANUFACTURED UNDER EXCLUSIVE PATENTS)
WHICH CAN GIVE YOU RANSOME RESULTS
IN
CONCRETE MIXING
THAT IS THE
ALL-BRITISH
RANSOME
THE MACHINE WHICH NEEDS NO ARISTOCRATIC INTRODUCTION.

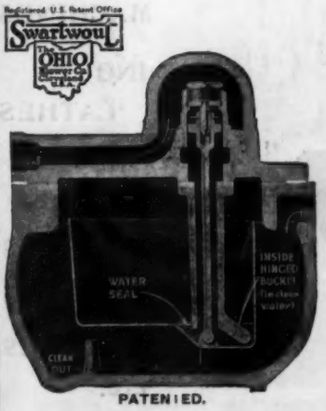
RANSOME-VERMEHR MACHINERY CO., LTD.
Telephone—2188 VICTORIA. 14/16, GROSVENOR GARDENS, WESTMINSTER, S.W. 1, [Cables—VERMEHRICO, LONDON. 4154

STEEL STRUCTURES
ROOFS, BRIDGES, TANKS

CLYDE STRUCTURAL IRON CO., LD.
CLYDESIDE IRON WORKS, SCOTSTOUN, GLASGOW.
Telegrams: CORRUGATED, GLASGOW.
Telephones WESTERN 2952-2953.

THE RAPID GIRDER SAWING MACHINE
WILL MITRE A 20" GIRDER AND IS SPECIALLY DESIGNED FOR SAWING ROLLED JOISTS & SECTIONS UP TO 20" × 12"
EDWARD G. HERBERT, LTD., ATLAS WORKS, LEVENSHULME, MANCHESTER. 6070
TELEGRAMS: "TESTED MANCHESTER."

Swartwout
Hydromatic TRADE-MARK STEAM TRAPS.



PATENTED.

THE Swartwout Hydromatic Steam Trap is a highly economical steam-saver. Using two of Nature's positive forces, buoyancy and gravity, the action is intermittent and positive. With only two moving parts the wear is reduced to a minimum. Water-sealed valve. Bucket float. Adaptable to any pressure up to 250 lbs.

Other Products: Steam, Air and Oil Separators; Exhaust Heads; Water Level Control Valves; Feed Water Heaters; Core Ovens; Ventilators; Ship Cowls; Sugar Entrainment Catchalls.

For further information apply to the Export Department,
THE OHIO BLOWER COMPANY,
CLEVELAND, OHIO, U. S. A. 7788

SMOOTH-ON

TRADE MARK REG. U.S. PAT. OFF.

IRON CEMENTS

Make permanent repairs of steam, water or oil leaks on iron and steel castings, boilers, engines, tanks, etc.

Every Engineer and Foundryman should have a copy of our new 144 page illustrated Instruction Book. It is free.

WALTER P. NOTCUTT, LTD.,
8, White Street, Moorfields, London, E.C.

Large stocks on hand ready for immediate delivery by

LONDON.	Messrs. F. A. PULLEN & CO., 58, Harleyford Road, Vauxhall, S.E. 11.
	BUCK & HICKMAN, Ltd., 2/4, Whitechapel Road, E.
LIVERPOOL.	Mr. JOHN TAYLOR, 10, Strand Street.
MANCHESTER.	THE WALMSLEY ENGINEERS' SUPPLY CO., 23, King Street West.
	A. DAWES & SONS, Ltd., 121, London Road.
HULL.	J. P. MOFFATT, 454½, Anlaby Road.
CARDIFF.	A. E. SMITHSON & CO., West Bute Street.
GLASGOW.	ANDREW McLEAN & CO., 109, Main Street, Bridgeton.

O 5108

BEWARE OF IMITATIONS.

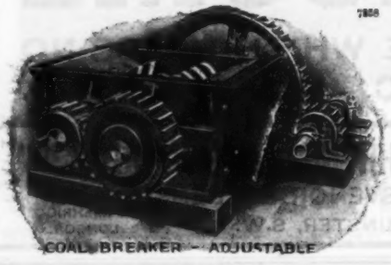
Send for New
No.16 Illustrated Instruction Book

DISINTEGRATOR-BEATER TYPE.

COKE BREAKER.

DISINTEGRATOR-BAR TYPE.

7858


COAL BREAKER—ADJUSTABLE.

BARRY HENRY & CO. LTD.

FOUNDERS & GENERAL ENGINEERS,

ABERDEEN.

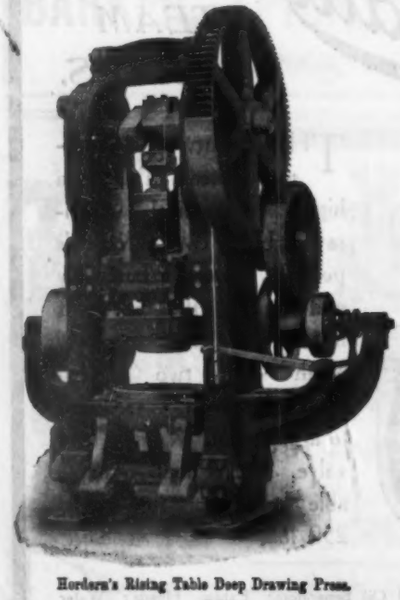
TRANSMISSION OF POWER AND TRANSPORTING MACHINERY SPECIALISTS.

DISINTEGRATING, CRUSHING, AND SCREENING MACHINERY FOR ALL CLASSES OF MATERIAL.

LONDON OFFICE:
155 FENCHURCH ST.,
E.C.

POWER PRESSES

FOR WORKING SHEET METALS,


Horden's Rising Table Deep Drawing Press.

GUILLOTINES,

CIRCLE CUTTING MACHINES,

SPINNING LATHES,

THREAD ROLLING MACHINES,

FRICTION PRESSES,

etc.

HORDERN & MASON,

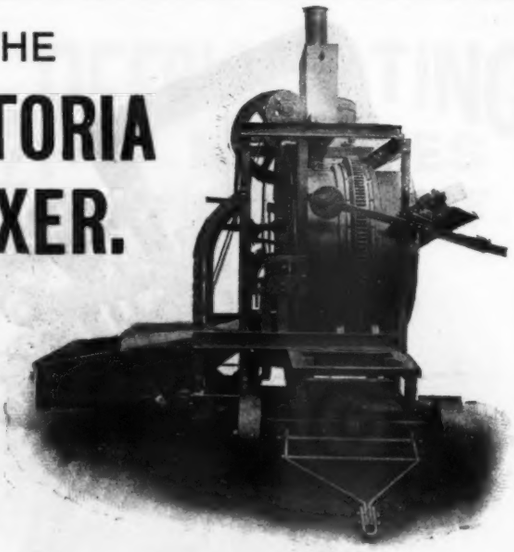
ENGINEERS, ST. MARY'S, (A. W. HORDERN, PROPRIETOR.)
BIRMINGHAM, ENG.

6004

Works Established 34 years. Telephone—Central 3527.

THE

VICTORIA MIXER.



PLANTS SPECIALLY DESIGNED AND CONSTRUCTED FOR DOCK WORK.

THE VICTORIA MIXER DEALS SUCCESSFULLY WITH
CONCRETE, ORES,
GLASS BATCH, FERTILISERS.

7633

Mixers in Stock Ready for Immediate Delivery.

Full Particulars from

STOTHERT & PITT, Ltd.,
38, VICTORIA STREET,
LONDON S.W. 1.

GRAVES'
Patent Fireproof Roofing

is unequalled for covering Sawmills, Timber Sheds, and Factory Buildings of all descriptions. It is slightly more expensive than most Roofing Felts on the market, but once laid it makes a permanent roof, and its proved fireproof qualities give it an obvious advantage over other similar materials. Unlike most Roofing Felts, Graves' Patent Roofing lies perfectly flat on the roof.

Over fifty years on the market
— Once used always used —

Quotations given for Roofing fixed complete on customer's boarding.

7609

Catalogue, samples and prices from:—

GRAVES & CO., Ltd., Oriel Chambers, 14, Water Street, Liverpool; or

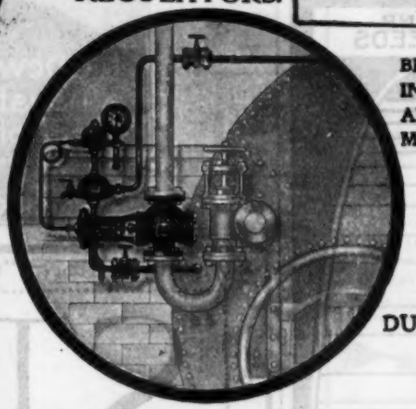
GRAVES & CO., Ltd., Finsbury Court Finsbury Pavement, London, E.C.2.; or

GRAVES & CO., Ltd., 45, Hope Street, Glasgow. [Established 1811].

CROSBY

BOILER FEED REGULATORS.

HUNDREDS OF REPEAT ORDERS.



BRITISH INVENTION AND MANUFACTURE.

IT HAS PROVED DURABLE AND RELIABLE.

7603

Crosby Valve & Engineering Co., Ltd.,
167, Queen Victoria Street, LONDON, E.C.

ELECTRO-MECHANICAL
BRAKES.

ELLISTON, EVANS & JACKSON, LTD.
13, CROSS STREET, FINSBURY, E.C. 2.
Telephones: London Wall 215 & 7303. Telegrams: "Elevanja, Finsquare, London."

GOLDEN WALKERITE
COMPRESSED ASBESTOS FIBRE
JOINTING

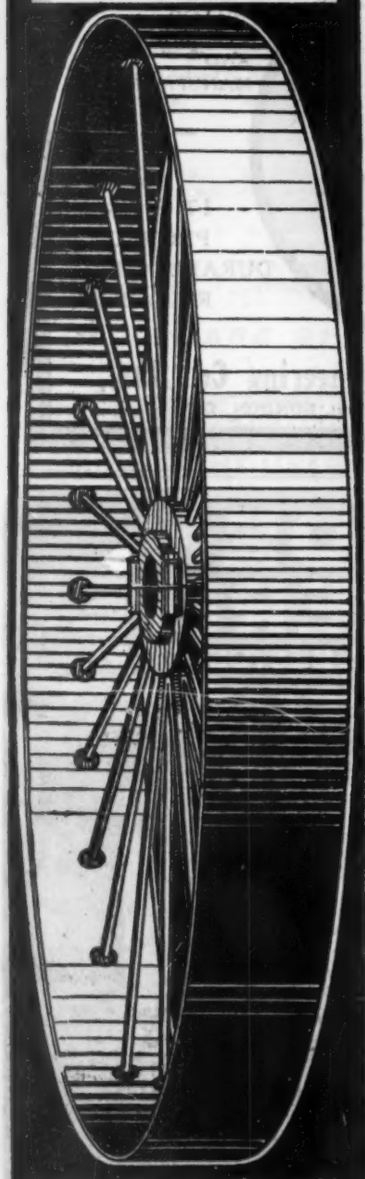
FOR STEAM WATER AMMONIA PETROL OIL, ACIDS

SUPERCEDES LEATHER & GUTTA PERCHA FOR HYDRAULIC JOINTS

CONTRACTORS TO H.M. GOVERNMENT
AND MANUFACTURERS
JAMES WALKER & Co LTD
Lion Works, Garford Street, West India Dock
LONDON, E.

DOUGLAS, LAWSON & COMPANY.

BIRSTALL NR. LEEDS



PULLEYS WROUGHT IRON

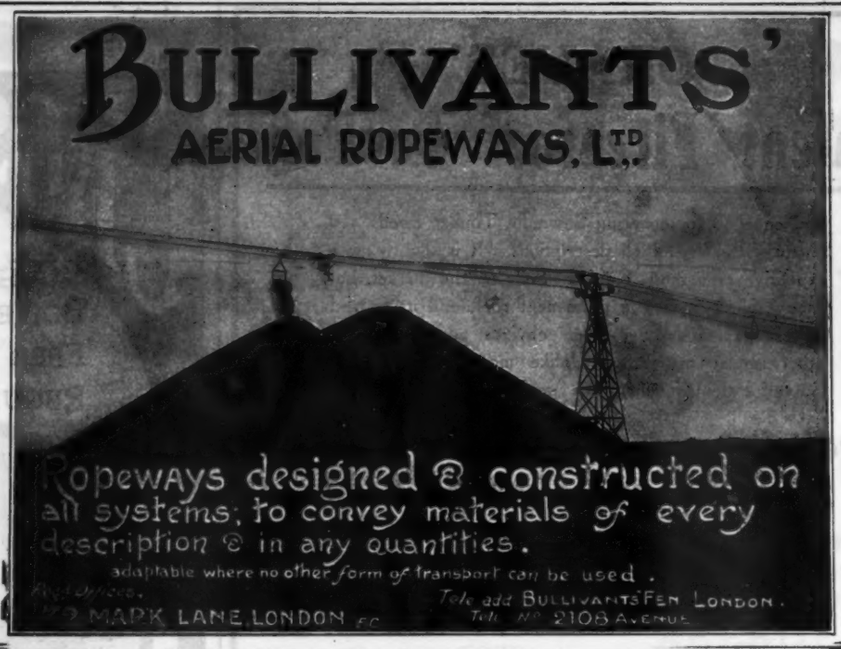
A SOLE SPECIALITY

TELEGRAMS — PULLEYS, BIRSTALL.
TELEPHONE — 155 BATLEY.

15

BULLIVANTS'

AERIAL ROPEWAYS, LTD.



Ropeways designed & constructed on all systems; to convey materials of every description & in any quantities.

adaptable where no other form of transport can be used.

Registered Office: 72 MARK LANE LONDON EC

Tele add BULLIVANTS FEN LONDON. Tele No 2108 AVENUE

6481

Opinion of large user. "COULD NOT REPLACE IT AS REGARDS QUALITY"

FIRST IN 1882

"STAUFFER'S LUBRICANT"

REG TRADE MARK

FOREMOST EVER SINCE

THE STANDARD MACHINE GREASE MADE SOLELY AT OUR WORKS IN LONDON FOR 30 YRS

TELL-TALE

STAUFFER'S

7844

PATENT "TELL-TALE" & "UNBREAKABLE"

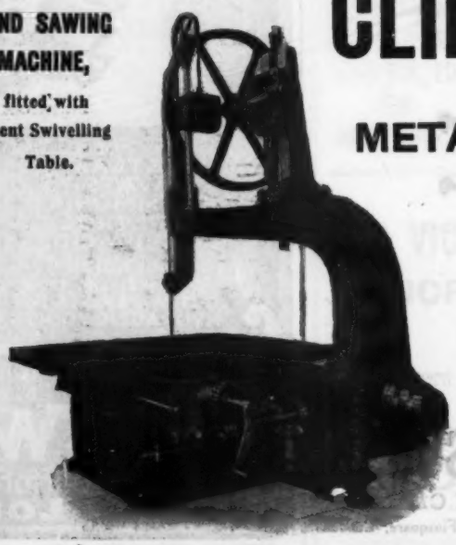
LUBRICATORS

FLUTED CAP UNBREAKABLE SHANK

TRIER BROS LTD 30 VICTORIA ST LONDON S.W.1
WORKS: NEW CHURCH RD S.E.5.

GUARANTEED GREASE TIGHT THREADS ON LUBRICATOR CAPS & SHANKS

BAND SAWING MACHINE, fitted with Patent Swivelling Table.



CLIFTON & WADDELL

Oldest Established Firm in Scotland of

METAL SAWING SPECIALISTS

HIGH-SPEED

Machine Tool Makers.

JOHNSTONE, near GLASGOW.

BAND SAWS - CIRCULAR SAWS
HOT SAWS - DISC SAWS -

BEST AND MOST UP-TO-DATE DESIGNS.

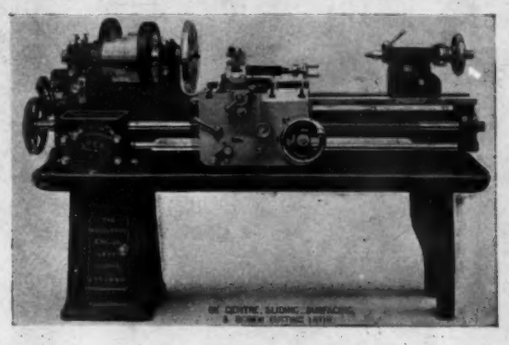
Over 1000 Machines in use.

7078

REDUCE YOUR PRODUCTION COSTS

A very large number of these Tools were supplied to the M. of M. and the Admiralty during the War for use on HIGH-CLASS PRECISION WORK.

Suitable for either TOOLROOM or Manufacturing purposes.



BY BUYING "APEX" LATHES.

Your policy is, we are sure, to have the BEST, and the BEST is always the CHEAPEST.

That is the reason why you should consult us regarding 6½ in. LATHES. Send for Illustrated List TO-DAY.

THE MOORLANDS ENGINEERING CO., LTD.,
LEEK, TELEPHONE 161. STAFFS.
LONDON:—FRY'S, Ltd., 46, Upper Thames Street. 7884 NEWCASTLE-ON-TYNE:—E. CLEATON REES & CO., 1, Eldon Square

WELLS' INCANDESCENT OIL LAMP.

IMPROVED PATTERNS.

A Cheap, Brilliant, and Shadowless Light from Paraffin or Petroleum. For Inside and Outside Lighting.

Stormproof, Simple and Economical.

300 to 1000 CP.

With Removable Vaporiser, quickly detached and readily cleaned, without displacing globe or mantle.

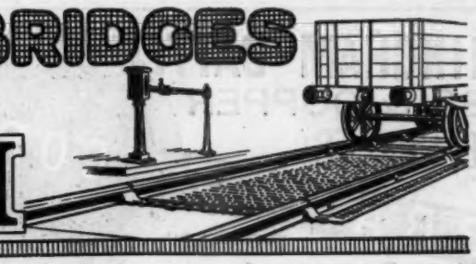
WELLS' "LIGHTNING" PAINTER.
(Wallwork & Wells' Patents.)
PAINTING BY MACHINE.

GREAT SAVING IN TIME, PAINT AND LABOUR.

OVER 700 SOLD.

PAINTING SPEED—8 sq. yds. a minute.
The paint is sprayed evenly and continuously through a flexible tube and nozzle, supplied with compressed air, either from existing air main or from our special compressors.

WEIGHBRIDGES



SAML DENISON & SON LTD. FAR HUNSLET LEEDS

7105

London Office: 28, Victoria Street, Westminster, S.W. 1.
Telegraphic Address: "Denwatest Vic, London." Telephone: 1883 Victoria.

KETTLE TORCH LAMPS.
THE MINER'S FAVOURITE.
THOUSANDS SOLD.
Used exclusively by De Beers, Randt Mines, etc.
Also largely used by Contractors, Corporations, Collieries, etc.

LARGE FLAMING LIGHT.

WELLS' TORCH LAMPS.

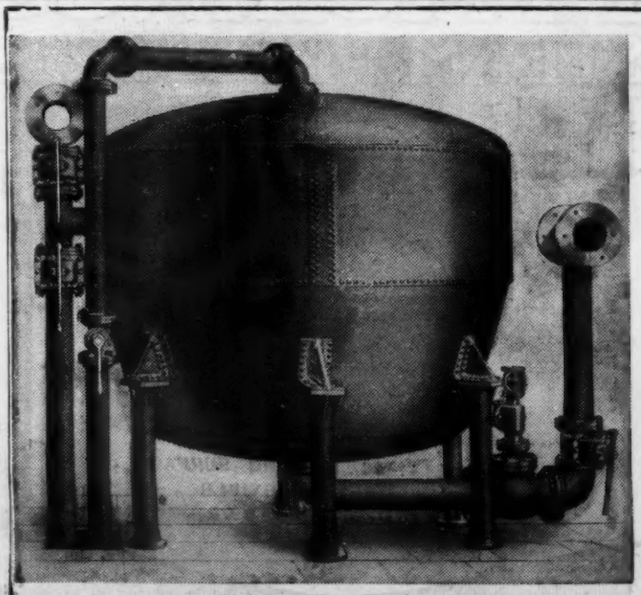
For Sperm, Rape, Colza, or other heavy Smokeless Oil. Also used for Kerosene.
No. 8, ½ pint, Hook No. 3.
No. 8a, ¾ pint, Hook No. 3.
No. 8z, 1 pint, Hook No. 3.

WELLS' Removable Bung-Pour.

7478

Also made in GUNMETAL.
For Emptying Cask without Pump, Tap, or Stillage.
Applied to and removed from any cask instantly. All waste and mess prevented. Runs rapid in action than a pump. Will fit any ordinary cask from 10 to 60 gallons.

A. C. Wells & Co. 102 Midland Rd., London N.W. 1.
Works: Carnarvon St., MANCHESTER.



ROYLES PRESSURE FILTER.

Largely used for filtering River, Canal, and other Waters for Manufacturing purposes.

All matters in suspension removed, and a clear water produced from turbid sources.

Cleansed in 5 minutes by means of Steam Air Injector and back flush of water.

Waters analysed, and advice on treatment for any particular requirements free of charge. 8335

ASK FOR CATALOGUE.

ROYLES LIMITED,
ENGINEERS AND SPECIALISTS.
IRLAM, nr. MANCHESTER.

WALTER NEWBOLD & Co. Ltd.
(Proprietors of Newbold's Machine Tool Co.),
25, Martin Lane, Cannon St., London, E.C.4.
Telegraphic Address:—NEWBOLD, LONDON.

LATHES and MACHINE TOOLS
of every description 8139
Also WOODWORKING MACHINERY.

OVERHEAD
ELECTRIC CRANES
AND
LOCO. STEAM CRANES.

ALEXANDER JACK & CO.,
Whitegates Eng. Works,
MOTHERWELL.

ARTHUR LEE & SONS LTD.

CROWN STEEL & WIRE MILLS, SHEFFIELD.

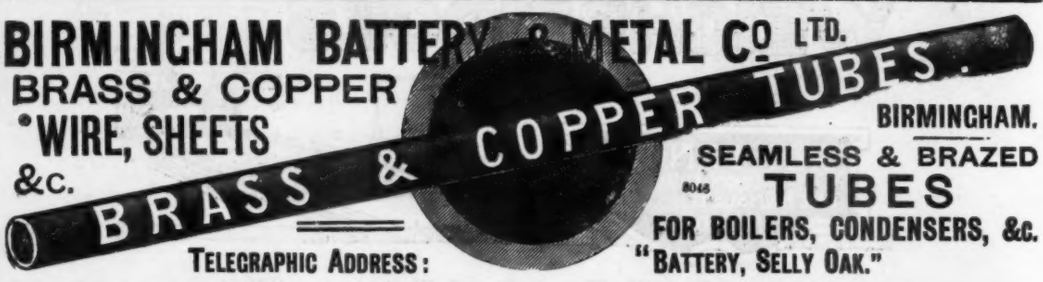
John Thompson
WOLVERHAMPTON
Superheaters

(Patent No. 1317 of 1917.)

Right and Left Hand Box Thread. By tightening or releasing this, the tube is fixed or removed in less than a minute

REDUCE YOUR COAL BILL.

BIRMINGHAM BATTERY & METAL Co LTD.
BRASS & COPPER
WIRE, SHEETS
&c.



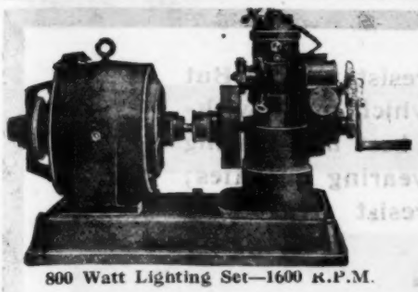
BIRMINGHAM.
SEAMLESS & BRAZED
8048 TUBES
FOR BOILERS, CONDENSERS, &c.
TELEGRAPHIC ADDRESS: "BATTERY, SELLY OAK."

V PILOT PACKINGS
FOR HIGH STEAM PRESSURES

Sole Patentees . . .
and Manufacturers
The
BELDAM
PACKING & RUBBER CO., LTD.
29 Gracechurch Street,
LONDON, E.C. 3.
Works—
BRENTFORD, MIDDLESEX.
'Grams: "Corrugated, Grace, London."
'Phone: Avenue 5204. Code: A B C, 5th Edition.

STOCKS
held at Branches
LIVERPOOL, GLASGOW,
CARDIFF, NEWCASTLE,
SOUTHAMPTON.
and official Ports throughout the World.

THE METALLIC BEARING SURFACE
IS A SINGLE FLEXIBLE
WHITE METAL BAR.



800 Watt Lighting Set—1600 R.P.M.

SMALL HIGH SPEED
INTERNAL COMBUSTION **ENGINES.**

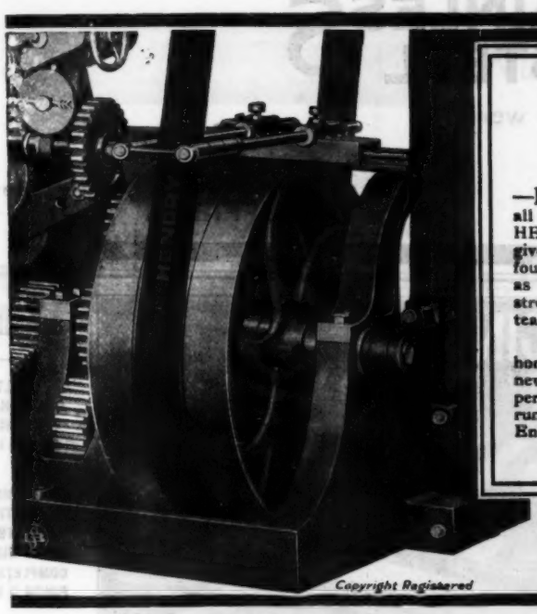
1½ B.H.P. ——— 1 K.W.

DIRECT COUPLED SETS
For driving DYNAMOS, PUMPS, COMPRESSORS and ALL SMALL POWER PURPOSES.

7868

AGENTS WANTED ABROAD.

RENDLE, BLANCHARD & CO. Ltd.
5, VICTORIA ST., LONDON, S.W. 1.



Copyright Registered

HENDRY
FROM A SINGLE STRAND
BELTING

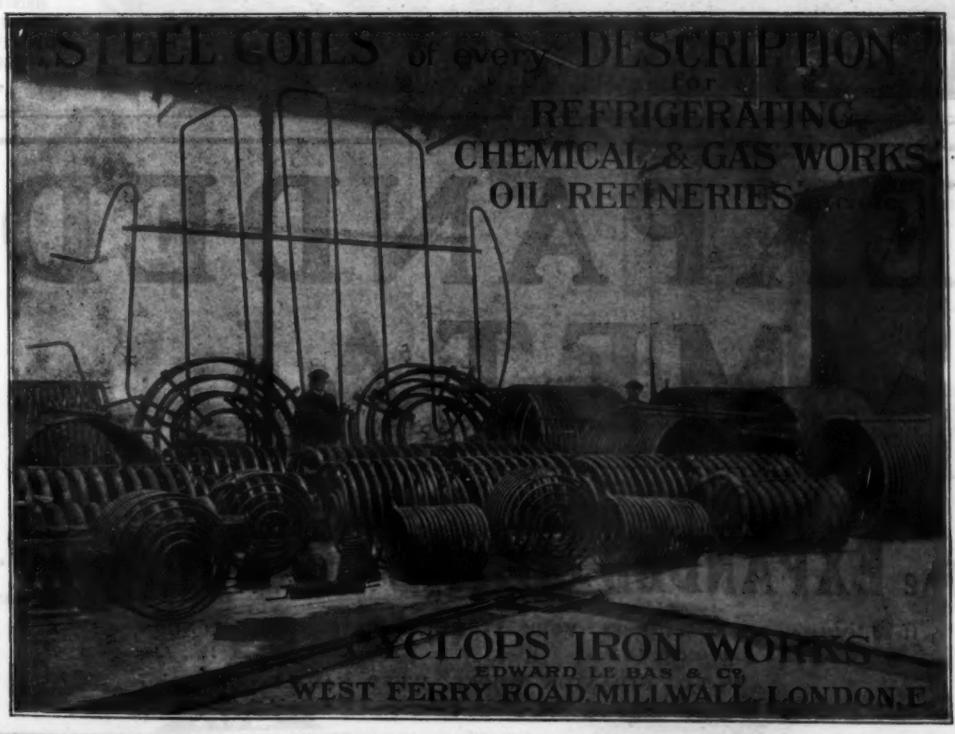
—For Planing Machine, Lathe and all classes of Heavy Machine Tool Driving, HENDRYS' new patent Flexible construction gives a peculiar Elasticity and Spring not found in any other Belting, and which acts as a cushion against heavy and irregular stresses, and reduces stretching and wear and tear to a minimum. . . . . .

The experience of the largest concerns at home and abroad proves that HENDRYS' new patent Laminated Leather BELTING permits of higher speeds, heavier cuts, steadier running, and an all round increase of output. Enquiries invited. . . . . .

Illustrated Booklet on request.

JAMES HENDRY, LTD.
252 Main Street
Bridgeton, GLASGOW

7311



6227

HARVEY
Engineering Co.,
LATE LTD.,
M'ONIE, HARVEY & CO., LTD.
Scotland Street Engine Works,
Head Office: 224, West Street,
GLASGOW.
London Office: 27, Mincing Lane, E.C.

ESTABLISHED OVER 50 YEARS.

MAKERS OF ALL KINDS OF
SUGAR MILLS
INCLUDING
PATENT FIVE ROLLER MILLS.

HARVEY'S
Triple-Effet . . . . Evaporator
Now in use in all Sugar Growing Countries.
AND EVERY REQUISITE FOR
Sugar Plantations.

SPECIALTY.
SUGAR REFINERIES
fitted up complete for refining all classes of sugar.

HIGH-CLASS
ENGINES
OF THE HEAVIEST TYPES.
MULTITUBULAR, CORNISH
AND
LANCASHIRE BOILERS.
TANKS & WROUGHT IRON WORK
OF EVERY DESCRIPTION.

6237

Telegraphic Address: "Masonic, Glasgow."
Cable Codes used: A B C, A1, Liebers, Western Union, Engineering and New Business.

A high-speed twist drill that bears the *"Chatwin"* stamp can be depended upon!

It is adapted for use in the hardest and toughest materials—under the most severe drilling conditions.

It is made for hard service by special methods of manufacture and is guaranteed as to shape, clearance and perfect temper.

7199

THOMAS
CHATWIN
LIMITED
VICTORIA WORKS
BIRMINGHAM.

O.E.C.

No Rust-proof Coating will resist wear. But there are many running parts which must withstand both wear and rust. The best non-rusting metals, in the past, had poor wearing qualities; the most suitable steels to resist wear were certain to rust.

FIRTH'S STAINLESS STEEL

7815

defies both rust and wear.

THOS. FIRTH & SONS LTD., SHEFFIELD.

Specialities.

BUILT CRANKSHAFTS FINISHED COMPLETE.

TUNNEL SHAFTING ROUGH TURNED AND FINISHED COMPLETE WITH BOLTS & NUTS.

PROPELLER SHAFTS FORGED FROM PURE SCRAP IRON, INGOT STEEL OR NEW BAR IRON TURNED AND FINISHED COMPLETE WITH GUN METAL LINERS.

6987

EXPANDED METAL.

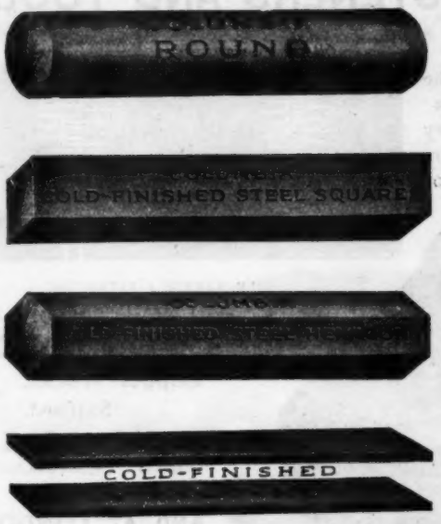
For PRICES, SAMPLES, etc., apply to—

The EXPANDED METAL COMPANY, LTD.

6913

Head Office: YORK MANSION, YORK STREET, WESTMINSTER, LONDON, S.W. 1.
Telephones: Victoria 8809 (2 lines). *Telegrams: "Distend, Vic., London."*

Works: STRANTON WORKS, WEST HARTLEPOOL.
Telephones: West Hartlepool 94 (2 lines). *Telegrams: "Extension, West Hartlepool."*



"Columbia" Bright Cold Drawn Mild Steel Rounds, Squares, Hexagons, Flats, and Special Shapes.

Free cutting, uniform throughout, and true to size. Suitable for case hardening.
Supplied well greased in 5 cwt. cases.

"Columbia" Turned and Polished Shafting.

All bars absolutely true to gauge and accurately straightened.

Telegrams: Integral, Holb., London.
Telephone: No. 1562 Holborn.

COLUMBIA STEEL & ENGINEERING Co., Ltd., 334-6, Bank Chambers, 329, High Holborn, **London, W.C.1.**

The W. & B. 18" Duplex Mill in a busy repair shop.

THIS is an example of the wide scope of the W. & B. Mill, apart from its extensive use as a purely manufacturing machine.

There are lots of rush jobs constantly passing through this big repair shop, and this machine gets a large share of them.

The pieces shown are commutator end bearings for 250 H.P. traction motors. They have been re-bushed with bearing metal, and bored to 3⅝ in. diameter by 8½ in. long. The work on the left hand table is a cast iron cylinder for making piston rings.

The W. & B. Duplex Mill is a sure cost-reducer. It gives double output with only one operator, and it sets a high standard of accuracy.

Write us and we'll tell you why it will pay to get one in your shop.

WEBSTER & BENNETT, LTD.

W&B

Head Office and Works: COVENTRY.

C. C. DUNKERLEY and CO, Ltd.

Iron & Steel

from

WAREHOUSE STOCK.

STEEL JOISTS,
24" × 7½" to 3" × 1½".
STEEL CHANNELS,
15" × 4" to 2⅜" × 1 3/16".
STEEL ANGLES,
8" × 3½" to ⅜" × ⅜".
STEEL TEES,
6" × 6" to ⅜" × ⅜".
STEEL FLATS,
18" × ½" to ¼" × 3/16".
STEEL ROUNDS,
8½" to ¼" dia.
STEEL SQUARES,
5" to ¼" dia.
STEEL PLATES,
3/16" to ½" to 8' long.
In all Standard Sections, cold straightened, lengths to 42'.

A LARGE AND VARIED STOCK OF
CROWN IRON,
BEST, BEST SCRAP and BEST TURNING IRON,
HOOPS, SHEETS, CONVEX, &c., &c.
STEEL BRIDGE RAILS,
BRIGHT STEEL, &c.

IRON and STEEL
HOOPS FOR BALING,
Plain & Painted, a Speciality.

COMPOUND GIRDERS,
STANCHIONS, ROOFWORK and CONSTRUCTIONAL STEEL
Riveted up on the Premises from Stock Material.

THE "AJAX"
PATENT CONVEYOR TANK
for handling Metal Scrap, Coal, &c.

ENQUIRIES SOLICITED.
Section Book on application.

Telegrams: "AJAX, MANCHESTER." Telephone: 6490-5 (six lines).

STORE STREET
Iron and Steel Warehouses,
MANCHESTER.

UMEC

TO SCIENTIFIC INSTRUMENT MAKERS, SHIPBUILDERS, & ELECTRICAL, RAILWAY, TELEGRAPHIC, TELEPHONE, MOTOR and GENERAL ENGINEERS.

7196

By our Chemical Engraving and Dividing Process we produce

The UMEC INSTRUCTION and DIAGRAM PLATES, SCIENTIFIC INSTRUMENT DIALS and SCALES, NAVAL and MILITARY PROTRACTORS and CALCULATORS on IVORINE, CELLULOID, EBONITE & METALS.

Name Plates also Chemically Engraved on Metals, Ivorine, Etc.

UNITED METAL ENGRAVING CO., LD.

Contractors to the Admiralty and War Office,

40, HIGH BRIDGE, NEWCASTLE-ON-TYNE.

Tel. 1888 Central. Telegrams: Impression, Newcastle-on-Tyne.

OXY-ACETYLENE WELDING Co. LTD.,

21a, ST. VINCENT CRESCENT, GLASGOW.

Telegrams: "BRAZING." Telephone: CENTRAL 4612.

CONTRACTORS TO ADMIRALTY AND WAR OFFICE.

CASTING REPAIRS

up to 5 tons. 7011

MATERIAL.—STEEL, WROUGHT IRON, CAST IRON, ALUMINIUM, BRONZE, Etc.

PROCESSES. — OXY-ACETYLENE, ELECTRIC and CAST IRON, BRAZING.

BOLTS, STUDS, NUTS.

BRIGHT WORK A SPECIALITY.

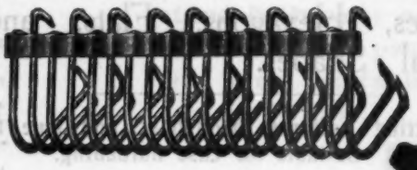
S. MARSDEN & SON, Ltd.

LONDON ROAD, MANCHESTER. 7001

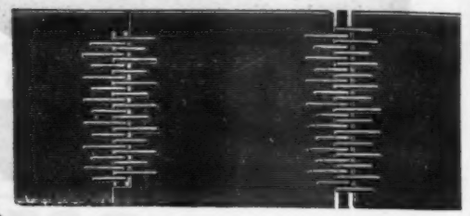
Telegrams— BOLTS, MANCHESTER. Telephone— 2021 CENTRAL (3 lines).

"KLINCHA" (PATENT) BELT FASTENERS AND TOOLS

(ORIGINATORS OF THE CLIPPER METHOD OF BELT LACING)



Keeps the World's Machinery in Motion.



Makes an absolutely Flexible Joint with the Maximum Economy.

No Knock or Jump.

COMPLETE OUTFIT SENT ON APPROVAL FOR ONE MONTH.

BRITISH MAKE.

SOLE MAKERS & PATENTEES:—

W. T. NICHOLSON & CLIPPER CO., LTD.,

Clipper Works, 6588 Salford,

MANCHESTER.

Telegrams: "Clipper, Manchester." Telephone: 4836 City.

AND AT LONDON.

THE

BRITON FERRY STEEL CO., LTD.

BRITON FERRY, SOUTH WALES.

Manufacturers of High-Class Steel by Siemens-Martin :: Acid and Basic Open-Hearth Processes. ::

STEEL.

For Tinplates, Sheets, Agricultural Implements, Wire, &c.

STEEL BARS.

In Small Rounds, Squares, Flats, and Hexagons. Sections and Light Rails.

STEEL BILLETS.

Dead Soft and Carbon Steel for all purposes. Welding and Case-Hardening Steel.

SPECIALITIES.

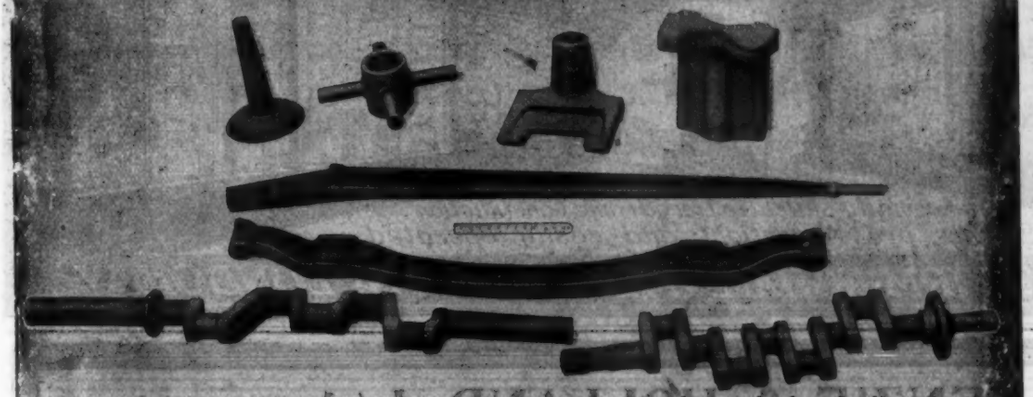
Alloy Steel for Aircraft and Motor Parts. Dead Soft Steel for Deep Stamping.

TRADE MARK—"VOLFER." 7010

CONTRACTORS TO THE BRITISH AND FRENCH GOVERNMENTS.

ALBION DROP FORGINGS CO., Ltd.

Works: Foleshill, COVENTRY.



We claim to have one of the longest experiences in the trade for dealing with all classes of Light and Heavy Drop Forgings.

DOBBIE - McINNES LIMITED,

INDICATORS
FOR STEAM & DIESEL ENGINES
and
PRESSURE GAUGES.

6731

ON ADMIRALTY LIST.

57, BOTHWELL ST., GLASGOW.

BRECKNELL, MUNRO & ROGERS, LTD.

Engineers and Contractors.

SPECIALISTS IN OVERHEAD LINES AND FITTINGS FOR ELECTRIC RAILWAYS AND TRAMWAYS IN INDUSTRIAL WORKS.

HIGH OR LOW TENSION LINES ERECTED IN ANY PART OF THE COUNTRY.

MAKERS OF PANTAGRAPH COLLECTORS FOR ALL TYPES OF ELECTRIC LOCOMOTIVES, CURRENT COLLECTORS FOR ALL PURPOSES, INSULATION OF ALL CLASSES, LINE EARS, SPLICING EARS, SUSPENSION FITTINGS, SECTION INSULATORS : : ETC., ETC.

7393

Let us Quote for your Requirements.

CATALOGUES ON REQUEST.

Head Offices: THRISSELL STREET, BRISTOL.

Telegrams: "Brecknell, Bristol." Telephones: 3137 and 3138 Bristol.

Standard Quality Oak and Chrome Tanned LEATHER BELTING. Single, Double and Treble, sewn with Copper Wire, Hemp, or Laces. MAIN DRIVING BELTS, built on the most approved principles.

OAK AND CHROME TANNED

HYDRAULIC RAM LEATHERS.

PUMP BUTTS and HIDES for Export.
MOTOR CLUTCH LININGS. BLACKSMITH'S WHITE and BROWN APRONS. RAW HIDE MALLETS and HIDE FACED HAMMERS. ROUND GUT MACHINE BANDING up to 1 in. dia.

All kinds of Technical Leathers used in Mining, Engineering, Shipbuilding, Iron and Steel Making and Manufacturing Trades.

E. J. COOKE, Trinity Leather Works
Blackfriars, MANCHESTER.

Telegrams: "Hides, Manchester."
Telephone: Central 1544. 6698

PERFECT SAFETY

GUARANTEED BY THE

"LARRAD LOCK" PATENT NUT

THE TRIPLE LOCKING NUT WHICH DEFIES THE MOST INTENSE VIBRATION.

ADOPTED BY ALL LEADING ENGINEERS.

HOBDELL, WAY & CO., LTD.,
124-7, MINORIES,
LONDON, E.1.

TELEGRAMS: "HOBNAILS, LONDON."
TELEPHONE: AVENUE 3810. 6699

HOPE'S · LOK'D-BAR · SASH

WALLS of DAYLIGHT

Specially suited to Aerodrome Construction
Vents are Watertight and easily operated.

55, LIONEL St. BIRMINGHAM: 59, BERNERS St. LONDON, W.

McKENZIE & HOLLAND, Ltd.

Railway signalling of every description.

POWER SIGNALLING

carried out in conjunction with

The McKENZIE, HOLLAND & WESTINGHOUSE POWER SIGNAL CO., LTD.,

Head Offices: 58, Victoria Street, London, S.W. 1234

Telegrams: "Macksig, London." Works: Worcester, England. Telephone, 4760 Victoria. (Two Lines.)

CHEKKO

Brake & Clutch Linings

HAVE 30 YEARS' MANUFACTURING EXPERIENCE BEHIND THEM.

Are used by over 400 Collieries, many hundreds of Engineers, Crane Makers, &c., and a host of the leading Chassis Builders of motor wagons and cars, London and other Omnibus Companies, &c., at Home and Abroad. :: :: :: ::

Send postcard for sample, prices and terms, to the sole manufacturers,

CRESSWELLS' LIMITED,

WELLINGTON MILLS, BRADFORD, YORKS.

11, Bothwell Street, Glasgow; Baltic Buildings, Gloucester Place, Swansea; 44, 45, Exchange Buildings, New Street, Birmingham.

Telegrams: "Asbestos," Bradford. Telephone: 950 Bradford.

Contractors to the Admiralty, India Office, War Office, Crown Agents for Colonies, numerous British Railways, &c. 6302

Ship, Tank, Bridge, SIEMENS OPEN HEARTH STEEL *Firebox and Special Plates.*

On Admiralty and Board of Trade Lists.

BOILER PLATES

Soft Welding and Flanging Plates for Furnace and other purposes.

STEWARTS AND LLOYDS, LTD. 1710

41 OSWALD STREET, GLASGOW.

DAVID COLVILLE & SONS, LD.

GLENGARNOCK IRON & STEEL WORKS, GLENGARNOCK.

CLYDE BRIDGE STEEL WORKS, CAMBUSLANG.

DALZELL STEEL & IRON WORKS, MOTHERWELL.

Head Office: MOTHERWELL.

DALZELL STEEL — BOILER BRAND.

DALZELL STEEL — SHIP & BRIDGE BRAND.

DALZELL N.C. STEEL — NICKEL CHROME BRAND.

DALZELL NICKEL STEEL — NICKEL STEEL BRAND.

PLATES, RAILS, JOISTS & BARS

IN SOFT, MILD, MEDIUM, HIGH TENSILE, H.H. TENSILE, NICKEL AND ALLOY STEEL.

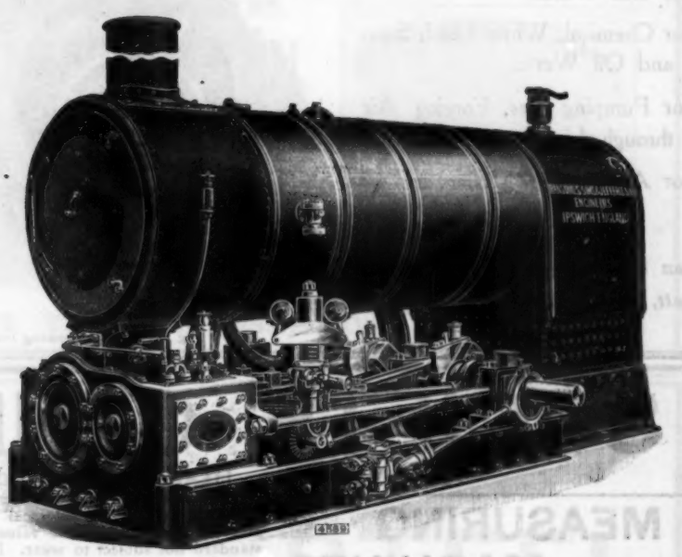
6404

COMPOUND UNDERTYPE STEAM ENGINES

CONDENSING AND NON-CONDENSING.

EFFICIENT & ECONOMICAL IN FUEL

From 24 to 190 Effective HP.



7635

RANSOMES, SIMS & JEFFERIES, LD.,

ORWELL WORKS, IPSWICH,

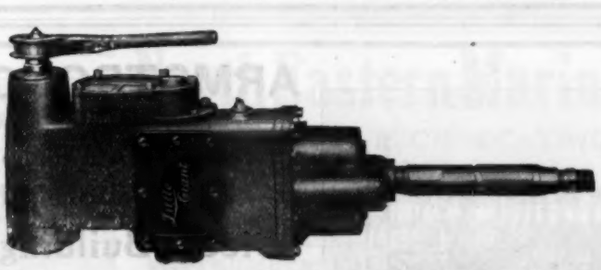
AND

46, QUEEN VICTORIA STREET, LONDON, E.C. 4.

LITTLE GIANT

Close quarter Drill. Made in two sizes.

The power of the motor is transmitted to the spindle through a compact train of gears, providing a steady uninterrupted rotation.



7231

LITTLE GIANT CLOSE QUARTER DRILL.

Has proved itself a real necessity. An easy to handle, powerful drilling machine for awkward corners.

THE CONSOLIDATED PNEUMATIC TOOL CO., LTD.

Head Offices: EGYPTIAN HOUSE, 170, PICCADILLY, LONDON, W.1.

WORKS: FRASERBURGH, SCOTLAND.

Telegrams:— "CAULKING, PHONE, LONDON."

BRANCHES ALL OVER THE WORLD.

ELECTRIC STEEL CASTINGS

FOR ALL PURPOSES FROM A FEW POUNDS IN WEIGHT.

MILD STEEL CASTINGS, LTD.,
HAYMILLS,
BIRMINGHAM.

7443

DONKIN

BLOWERS, GAS COMPRESSORS, EXHAUSTERS.
of the Positive type.
For INDUSTRIAL PURPOSES.

For Gas Works.
For Chemical, White Lead, Soap and Oil Works.
For Pumping Gas, Forcing Air through Liquor, &c.
For Agitating or Mixing, &c.

Can be arranged for driving by Belt, Steam Engine, Gas Engine, or Electric Motor.

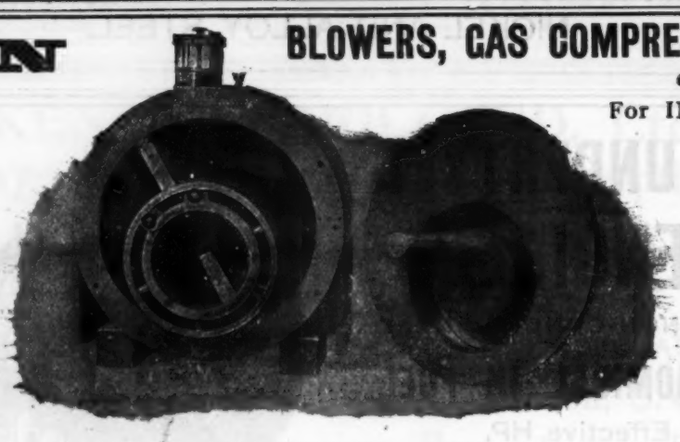


Fig. 659.—View showing Internal Parts of Machine.

Advantages and Features:—
Absence of all Valves.
Simplicity of Construction and small number of working parts.
Working parts entirely enclosed.
Good efficiency. Silent working.

THE
BRYAN DONKIN Co., Ld.,
Engineers, 7336
CHESTERFIELD, England.

SOCIÉTÉ GENEVOISE D'INSTRUMENTS DE PHYSIQUE.

HEAD OFFICES AND WORKS—GENEVA.

MEASURING MACHINES. Based on sound metrological principles. Give measurements in absolute values by the use of a standard not subject to wear. Do not require the use of expensive end measuring bars. Indispensable for controlling with certainty the measuring apparatus and gauges used in the mass production of mechanical parts. Ensure complete interchangeability of components. Installed in many well-organized engineering works, laboratories, and scientific institutions throughout the world. 7436

DIVIDING MACHINES. Circular, Linear and Drum types, automatic or non-automatic. Made in several sizes and degrees of accuracy, according to requirements and class of work.

ADJUSTABLE LIMIT SNAP GAUGES. Improved design, ensuring accuracy after adjustment or setting of measuring points. Suitable either for mass production or small quantities.

LIMIT SCREW GAUGES. B.S.W., B.S.F., B.S.P., S.I.

STANDARDS. English or Metric Units.

LONDON OFFICE AND SHOWROOM | Representative for United Kingdom - - - W. A. STEWARD. | Telegrams—Sogenique, Cent. London. Telephone—Central 7841. | 95, QUEEN VICTORIA ST., LONDON, E.C. 4.

ARMSTRONGS & MAIN, LTD.

(ARMSTRONGS ENGINE WORKS and A. & J. MAIN & CO., Ltd.)

GENERAL AND CONSTRUCTIONAL ENGINEERS AND CONTRACTORS.

Steel Buildings, Roofs, Bridges, Girders. 6675

TRESTLING FOR BUNKER PLANT, ETC.
DOCK STAGING. CRANE WORK.

CLYDESDALE AND GERMISTON WORKS, GLASGOW.
CALCUTTA BRIDGE & ROOF WORKS, CALCUTTA.

AUSTRALIA HOUSE, STRAND, LONDON, W.C.

First across the Atlantic.

ZENITH

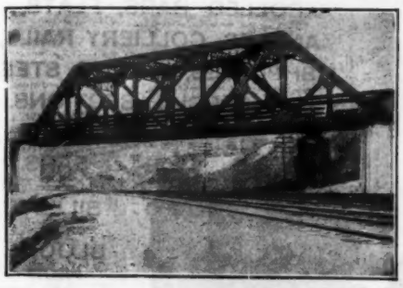
Carburetters

were fitted to the NC 4, convincing proof of reliability & efficiency

— Send for Booklet —

ZENITH CARBURETTER CO., Ltd. 40-42, Newman Street, LONDON. W. I. 7489 Telephone: Regent 4812-4813.

McCLINTIC-MARSHALL PRODUCTS COMPANY



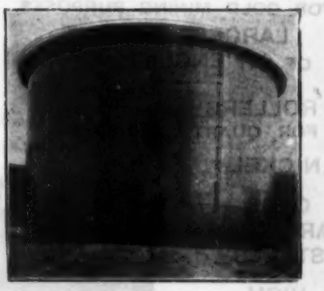
ENGINEERS AND MANUFACTURERS.

STEEL CONSTRUCTION

ANNUAL CAPACITY 400,000 TONS.

McClintic-Marshall Products Co.
Riter-Conley Manufacturing Co.
Union Shipbuilding Co.

Write for Catalogue S,
50, Church Street, New York, U. S. A.
Cable: MACMARSH, New York. 7400



BRIDGES—BUILDINGS—RIVETED PIPE—STORAGE TANKS—TRANSMISSION TOWERS—SHIPS

BRIGHT

COLD ROLLED FOR ALL PURPOSES.

DRAWN HEXAGON & ROUND

STEEL

BRITISH ROLLING MILLS, LIMITED,

Oliveland Street, 7435
BIRMINGHAM.

TELEgrams—"OCTAGON." Phone—Central 1869. 1870.

THE

North Eastern Marine Engineering Co., LIMITED.

Builders of RECIPROCATING and TURBINE ENGINES and BOILERS of all sizes and for all Classes of Vessels.

Sole Makers of the North-Eastern Grease and Air Extractor and Feed Heater, and Evaporator.

QUICK DELIVERY GIVEN of PROPELLERS and SHAFTS, also FORGINGS of every DESCRIPTION.

NORTHUMBERLAND FORGE,
WALLSEND-ON-TYNE.
Telegrams—"NEWS, WALLSEND."

LONDON OFFICE:
22, Billiter Street, E.C.
Telegrams—"Nemesis, Fen, London."
LIVERPOOL OFFICE:
529, Tower Building, Water Street.
Telegrams—"Exactly, Liverpool."
Tel. No. 1866 Central (Two Lines).

WALLSEND-ON-TYNE
(Head Office).
Telegrams—
"NEWS, WALLSEND."

SUNDERLAND.
Telegrams—
"NEWS, SUNDERLAND."

Manufacturers, under License, of SUPERHEATERS for Marine Boilers, and "WERKSPOOR" MARINE DIESEL ENGINES. 6978

ENGINES, BOILERS, &c. constructed for export, and fitting out supervised

ON ADMIRALTY LIST.

Telegrams: BESSEMER, SHEFFIELD.

Telegrams: BESSEMER, BOLTON.

HENRY BESSEMER & CO. LD.

SHEFFIELD,

STEEL MANUFACTURERS.

SPECIALITIES. AND AT BOLTON (LANCS.) SPECIALITIES.

FORGE INGOTS UP TO 25 TONS.

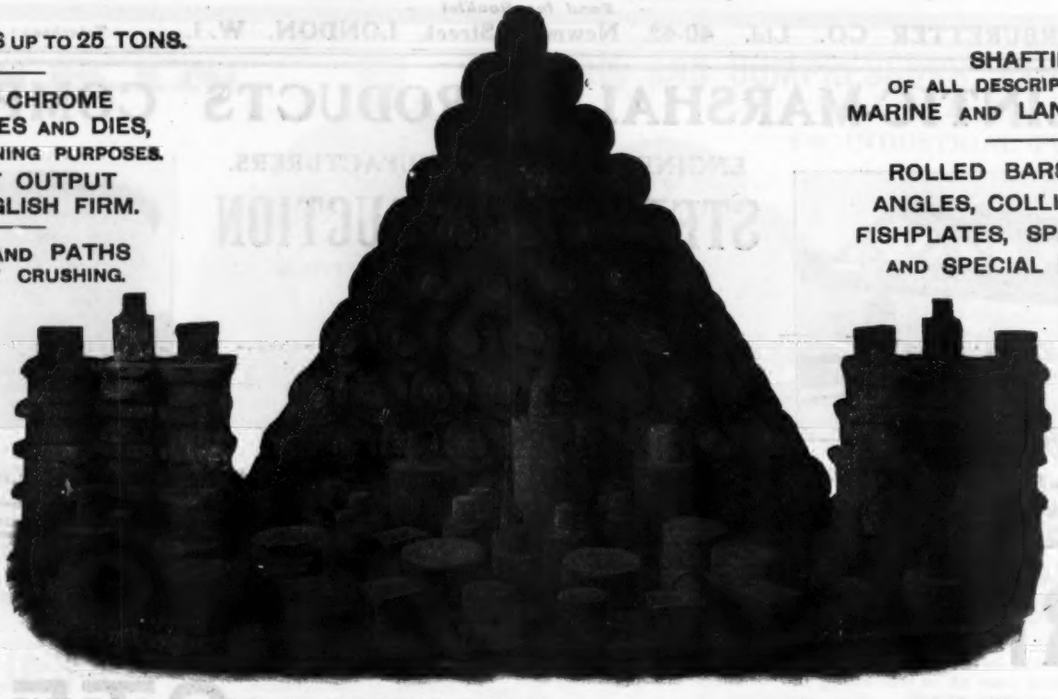
FORGED CHROME STEEL SHOES AND DIES, FOR GOLD MINING PURPOSES. LARGEST OUTPUT OF ANY ENGLISH FIRM.

ROLLERS AND PATHS FOR QUARTZ CRUSHING.

NICKEL & CASE HARDENING STEELS.

HIGH TENSILE STEEL FOR WIRE DRAWING & ORDNANCE WORK.

CONTRACTORS TO ADMIRALTY, WAR OFFICE, CROWN AGENTS FOR THE COLONIES.



SHAFTING OF ALL DESCRIPTIONS FOR MARINE AND LAND ENGINES.

ROLLED BARS, FLATS, ANGLES, COLLIERY RAILS, FISHPLATES, SPRING STEEL AND SPECIAL SECTIONS.

REELED BARS.

BILLETS & BLOOMS FROM 2"—12" SQ.

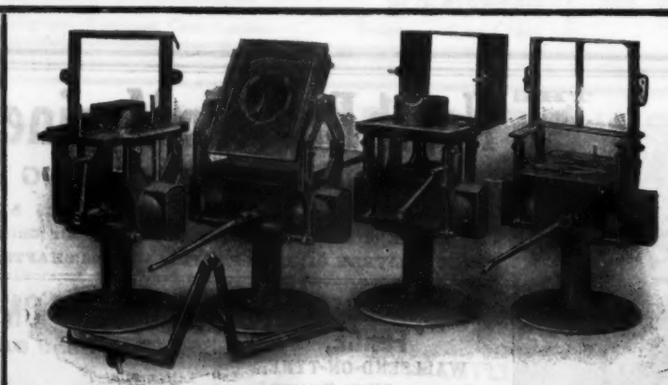
CONTRACTORS TO COLONIAL, INDIAN, & FOREIGN GOVERNMENTS, BRITISH & FOREIGN RAILWAYS, &c.

BUILT-UP AND SOLID CRANK AXLES, WITH GUARANTEED MILEAGE, AND CRANK SHAFTS, TYRES, AND AXLES OF ALL TYPES for Railways, Tramways, &c. 7949

SPECIAL HIGH-TENSILE TYRES, "ARGENTINE" BRAND, for Locomotives, &c.
WELDLESS CRANK HOOPS, BOILER RINGS AND ANGLE RINGS.

PROMPT DELIVERIES OF FOUNDRY EQUIPMENT.

MOULDING MACHINES.
CORE MACHINES.
SAND MIXERS.
MOULDING BOXES (CAST IRON OR STEEL).
SNAPFLASKS, AND ALSO FITTINGS.



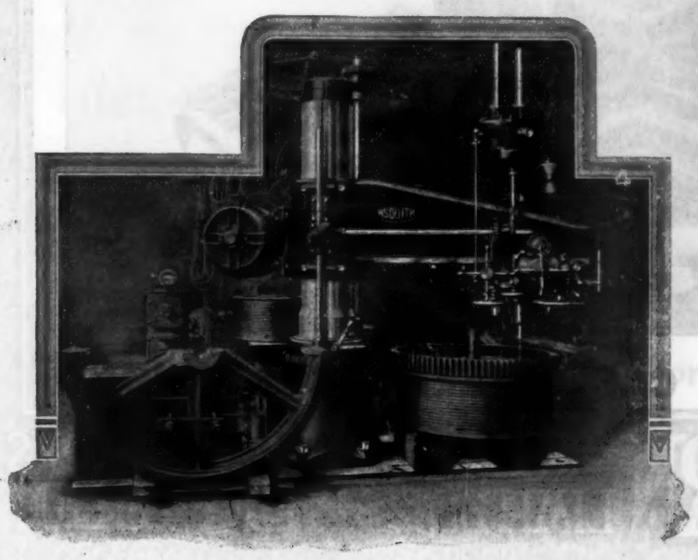
CUPOLAS.
HOISTS.
STAGINGS.
LADLES.
SHAKING BARRELS.
PNEUMATIC VIBRATORS

TELEPHONE No. MID. 1966.

ADAPTABLE MOULDING MACHINE Co.,
STANHOPE STREET, BIRMINGHAM.

TELEGRAMS "ADAPTABLE." 7519

"ASQUITH" DRILLS on the job.



Study the illustration opposite — it is worth more than a casual glance. One of our Central Thrust Radials, with triple baseplate, at work in a big Lancashire Engineering Works. Here they have recognised the advantages of this "Asquith" drill and find a heap of work for it every day.

We have ample proof of the satisfaction which our machines are daily affording in use, and this information is yours for the asking. Why not investigate the possibilities of "Asquith" machines before installing that next drill?

Full particulars of this type of drill are set out in our LIST R 18.

Your copy is ready. Why not write for it? A p.c. will be sufficient.

DRILLING ASQUITH MACHINES

(WILLIAM ASQUITH (1919) LIMITED),

Park Works, Halifax, England.

Codes: A B C, 5th Edition, and Lieber's.
Telephone: 1568 Halifax (4 lines). Telegrams: "DRILL, HALIFAX."

LONDON OFFICE

The Associated British Machine Tool Makers, Ltd,

34, Victoria Street, London. S.W. 1; with Branches at 4208

Manchester, Birmingham, Sheffield, Newcastle, Bristol, Leeds, Glasgow and Abroad.

Sterling Extruded Sections.

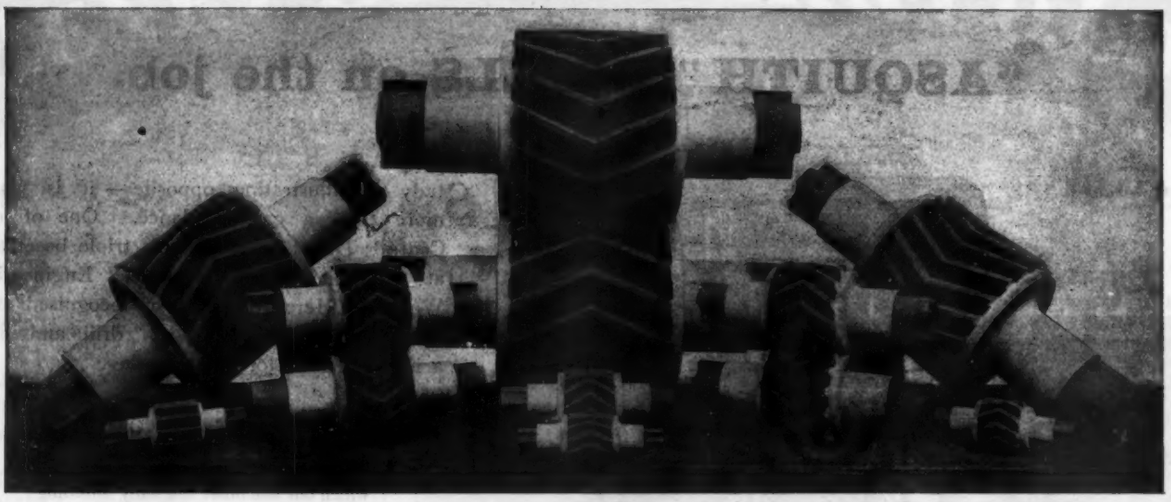
Aluminium, Brass & High Tension Bronze.

MADE to a very fine degree of accuracy; square, round and hexagon sections can be machined by automatics. The High Tension Bronze has an ultimate strength of 50 tons per square inch and is especially useful for pump rods, worm gear and any parts demanding a high degree of hardness and tensile strength or subject to corrosive influence of atmosphere or sea water. Aluminium Sections are one-third the weight — bulk for bulk — of brass and are especially suitable for use as mouldings where curves have to be fitted closely. The metal of the Brass Sections cuts very freely and is easily machined.

Sterling Metals Ltd., Coventry. Wires: Sternet, Coventry 'Phone: Coventry 661.

Founders in Aluminium, Gunmetal and Iron. 6058

STEEL CASTINGS.



OSBORN'S TOUGHENED CAST STEEL MILL PINIONS

SAMUEL OSBORN & Co. LIMITED CLYDE STEEL WORKS, SHEFFIELD.

SUN SHIP

STANDARD TYPE STEAMERS

SUN SHIPBUILDING CO.

BUILDERS OF

STANDARDIZED VESSELS

OF

12,000 TONS DEADWEIGHT,

ENGINE BUILDERS, BOILER MAKERS,

FOUNDERS, MACHINISTS.

4823

PLANT:
Chester, Pa. U.S.A.

GENERAL OFFICE
1428 Co. Penn Square, Philadelphia, Pa, U.S.A.

T. A. SAVERY & Co. Ltd.

Newcomen Works :: Birmingham :: England.

Telephone: *Central* 3599.

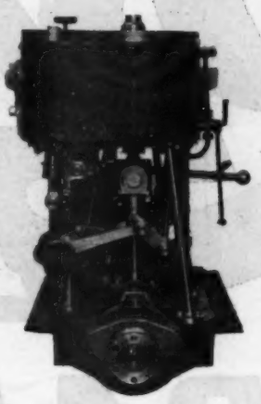
Telegrams: "*Newcomen, Birmingham.*"

Marine Engineers.

□

High-Speed Steam Marine :: Machinery.

□



4½ in. Triple-expansion Set.

Boiler Makers.

□

Oil or Coal Fired Water Tube or Shell Boilers.

7640

High-Class Machine Work of all Descriptions.

□ □ □

Expert Supervision and Accuracy Guaranteed.

JIG AND GAUGE WORK A SPECIALITY.

WILLIAM BEARDMORE & CO., LTD.,

Telegrams: "BEARDMORE, GLASGOW." "BEARDMORE, DALMUIR."

Contractors to Admiralty, Colonial and Foreign Governments.

WAR SHIPS, MAIL STEAMERS, CARGO VESSELS.

Steel Manufacturers, Forgemasters, Gun and Armour Plate Makers, Shipbuilders & Engineers. **GLASGOW.**

SHAFTS

Crank & Straight, Hollow & Solid.

SHIP & BOILER PLATES & SHEETS.

HYDRAULIC FLANGED

BOILER FRONTS, ENDS AND FLUES.

25 to 4000 HP. "BEARDMORE"

OIL ENGINES.

LOCOMOTIVES

OF ANY VARIETY

STEAM PETROL ELECTRIC

STEEL SECTIONS

OF ALL SIZES

AXLES (CRANK and STRAIGHT) **AND TYRES**

For LOCOMOTIVES, CARRIAGES and WAGONS.

WHEELS & AXLES

FINISHED COMPLETE.

NICKEL STEEL PLATES, SHEETS, BARS, SHAFTS and FORGINGS.

All facilities afforded for TESTING at the Works.

STEEL CASTINGS OF ALL DIMENSIONS.

Royce Ltd.

Trafford Park, MANCHESTER.

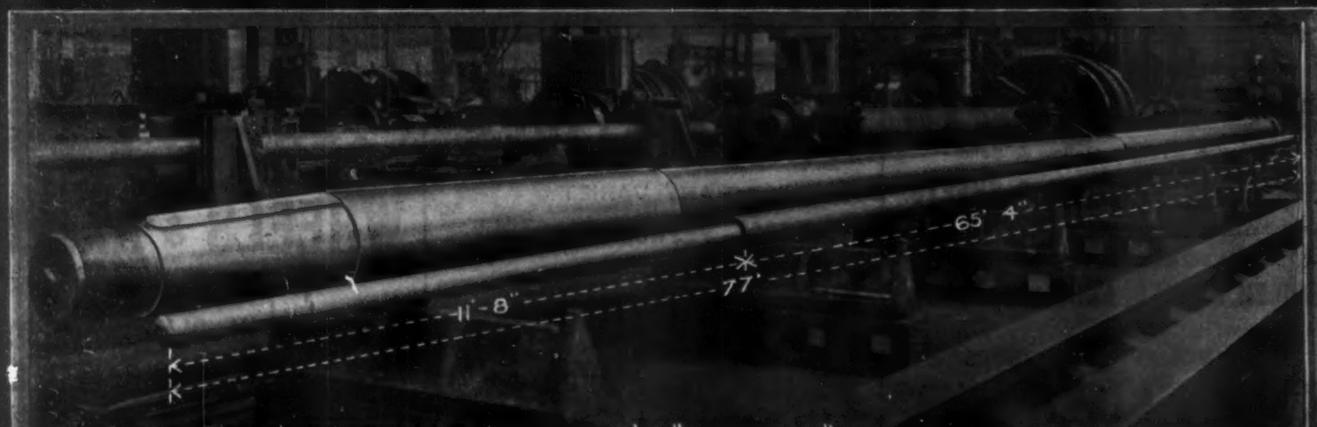
ELECTRICAL CRANES and WINCHES.

7748

STEEL & IRON

FORGINGS of HALESOWEN

SOMERS

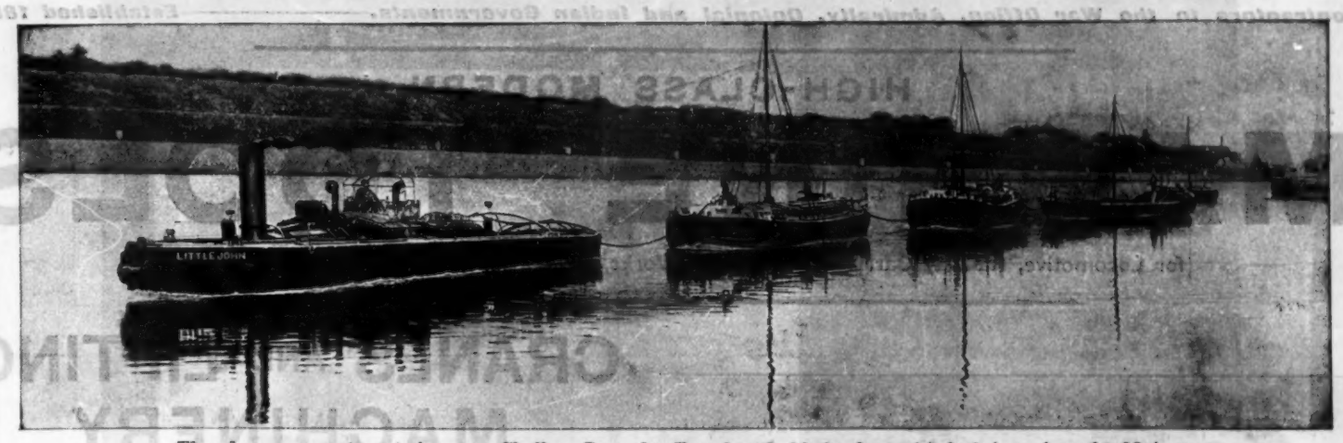


HOLLOW STEEL PROPELLER SHAFT 77'-0" LONG 17" DIA. WITH CORE TREPANNED OUT OF THE CENTRE, LYING ALONGSIDE.

POWERFUL TWIN-SCREW SHALLOW DRAUGHT TUG

built by

YARROW & CO., Ltd., Glasgow.



The above represents a twin-screw Shallow Draught Tug, length 80 ft., beam 14 ft. 6 ins., draught 22 ins., propelled by screws working in tunnels fitted with YARROW'S PATENT BALANCED HINGED FLAP, by means of which considerable increase of speed is secured without additional power or cost, and the maximum efficiency under all conditions of load is obtained.

Messrs. YARROW construct fast Passenger and Commercial Vessels, Shallow Draught Steamers, Tugs, &c., propelled by Sternwheels, Side Wheels, or Screws working in Tunnels fitted with Yarrow's Patent Balanced Hinged Flap.

REPAIRS ON PACIFIC COAST
by **YARROWS**, Limited, Victoria, British Columbia, Shipbuilders, Ship Repairers and Engineers.

1770

JAMES HOWDEN & CO., LD., GLASGOW.

MANUFACTURERS OF

"IMPULSE" STEAM TURBINES, SPECIALLY RECOMMENDED FOR LARGE UNITS.
HIGH-SPEED STEAM ENGINES.

LONDON OFFICES—

Caxton House,
Westminster, S.W.
and
8, Billiter Square, E.C.

750 KWT. "HOWDEN" MIXED PRESSURE TURBO GENERATOR
Installed at Noble's Explosives, Ltd., Stevenston, N.B.

MANCHESTER—
88, Cross Street.

NEWCASTLE—
90, Pilgrim Street.

BELFAST—
137, Royal Avenue.

PATENTEES AND MANUFACTURERS OF HOWDEN'S FORCED DRAUGHT; WALLSEND-HOWDEN OIL BURNING SYSTEM. PATENT COMBINATION WATER-TUBE BOILERS; AND VENTILATING FANS.

1965

JAMES HOWDEN & CO., LTD., GLASGOW.

CRAVEN BROTHERS (MANCHESTER) LIMITED,

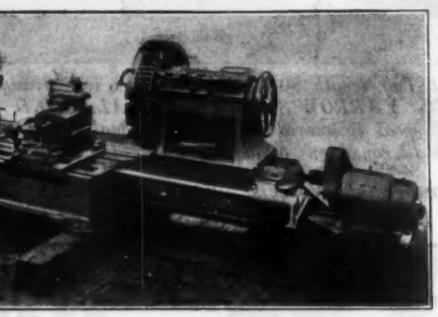
Telegrams:—CRAVEN, REDDISH. Vauxhall Works, REDDISH, STOCKPORT. Telephone:—No. 421 HEATON MOOR.

Contractors to the War Office, Admiralty, Colonial and Indian Governments. —— *Established 1852.*

HIGH-CLASS MODERN

MACHINE TOOLS

for Locomotive, Railway Carriage and Wagon Works, Ordnance, Marine and General Purposes.



Electrically-driven Railway Wheel Lathe for Carriage and Wagon Wheels

CRANES AND LIFTING MACHINERY

of all Types to any Capacity.

GROUND TRAVERSERS

for Locomotives and Carriages.

6434

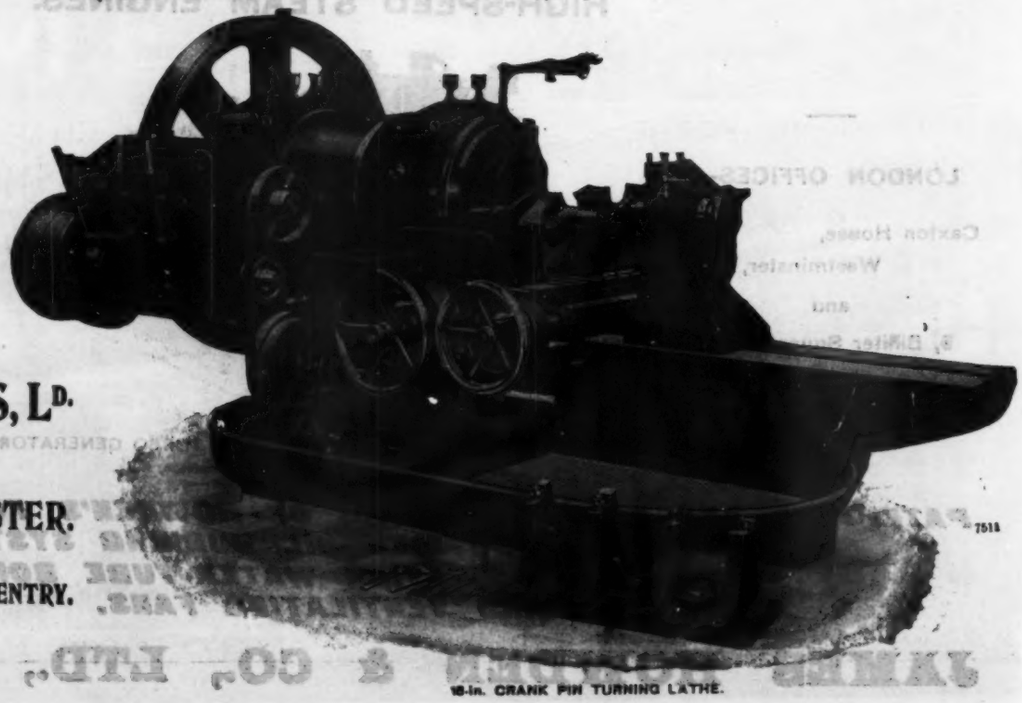
Quotations given for Castings up to ***40*** *tons weight.*

GARDNER PATENT CRANK PIN TURNING LATHE

ENORMOUS SAVING IN CRANK PIN MACHINING TIME.

(FULL PARTICULARS ON APPLICATION.)

An absolute essential where Cranks are machined in quantities!



7518

L. GARDNER & SONS, Ld.
Patricroft,
MANCHESTER.

Selling Agents:—
Messrs. A. HERBERT Ltd., COVENTRY.

Telegrams:—"THRONER, PATRICROFT."
Telephone:—401, ECCLES (4 lines).

18-in. CRANK PIN TURNING LATHE.

HOFFMANN

NOTE THE SHORT ROLLERS

ROLLER BEARINGS

THE HOFFMANN MFG. CO. LTD.
CHELMSFORD ——— ESSEX.

FROUDE DYNAMOMETER

Adopted by the Admiralty and War Office.

Scientifically designed for ascertaining the exact B.HP. of any description of Engine.

◈ ◈ ◈ ◈

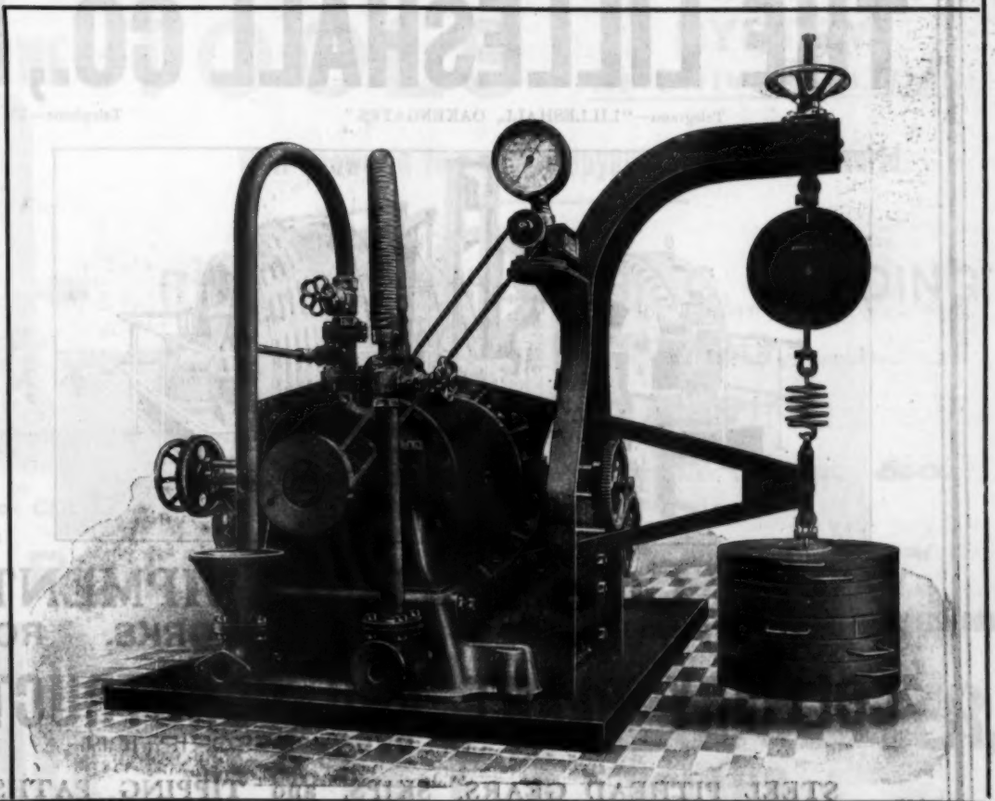
Indispensable for Test Shop Efficiency.

◈ ◈ ◈ ◈

Write for Catalogue,

HEENAN & FROUDE
LIMITED,
WORCESTER,
ENGLAND.

7389



SPANNERS.

Single and Double-Ended. All sizes up to 2" supplied from stock.

***SPECIAL SPANNERS* made for following trades:—**

ENGINEERING
SHIPBUILDING
CONSTRUCTIONAL
BRIDGE BUILDINGS
MOTOR CARS AND LORRIES

AGRICULTURAL IMPLEMENTS
RAILWAY PERMANENT WAYS
MACHINE TOOLS
LOCOMOTIVES
WATER DEPARTMENTS

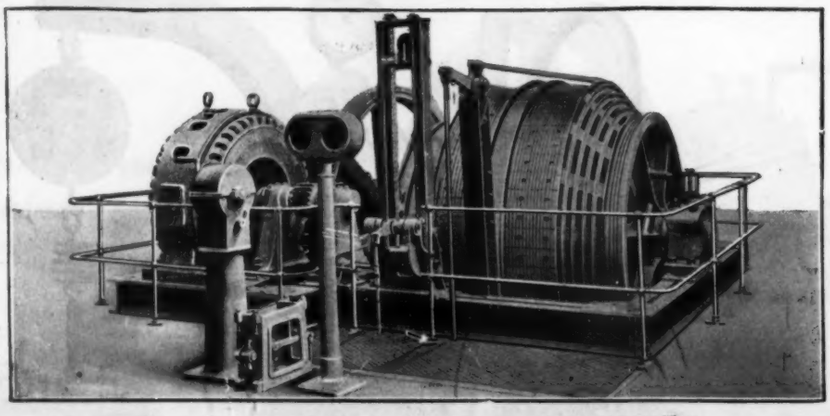
ARMSTRONG, STEVENS & SON, LTD., WHITTALL ST., BIRMINGHAM.

WORKS:—WILLENHALL.

PRICES QUOTED ON APPLICATION.

THE LILLESHALL CO., LTD. OAKENGATES, SHROPSHIRE.

Telegrams—"LILLESHALL, OAKENGATES." Telephone—28, OAKENGATES.



ENGINES

for Winding, Hauling, Blowing, Pumping, Rolling.

UNIFLOW ENGINES,

GAS ENGINES,

400 to 4000 B.HP.

COKE OVEN PLANT.

COMPLETE EQUIPMENTS :—

BLAST FURNACES. STEEL WORKS. ROLLING MILLS. 7302

COLLIERY PLANT AND CONSTRUCTIONAL WORK

OF EVERY DESCRIPTION.

STEEL PITHEAD GEARS, SKIPS, and TIPPING PATHS. PIT CAGES.

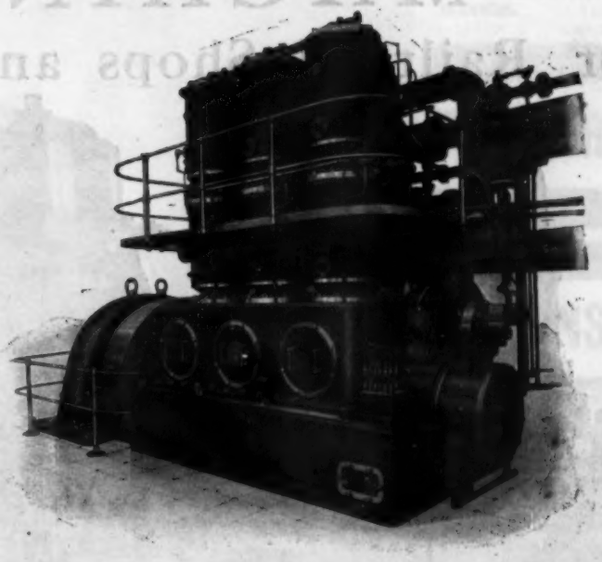
THE
National Gas Engine Co.
LIMITED.

YOU CANNOT

CHOOSE YOUR OWN PRICE WHEN PURCHASING FUEL FOR POWER PURPOSES, BUT

YOU CAN

CHOOSE YOUR OWN FORM OF MOTIVE POWER, AND BY INSTALLING A "NATIONAL" ENGINE YOU WILL THEREBY REDUCE YOUR COSTS TO A MINIMUM.



450 HP. ENGINE AND ELECTRICAL GENERATOR.

WORKS and OFFICE : Ashton-under-Lyne, MANCHESTER.

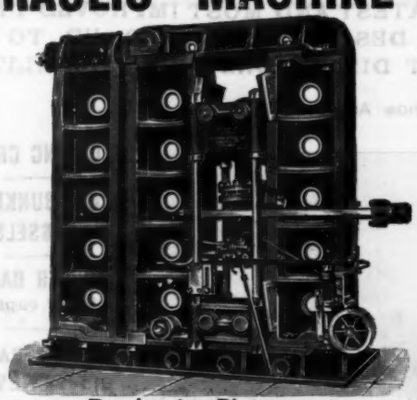
LONDON SHOWROOM : 75a, Queen Victoria Street, LONDON, E.C. 4.

SHIPBUILDERS' TOOLS

HYDRAULIC MACHINE

TWEDDELL'S SYSTEM IN UNIVERSAL USE

Well known in foremost shipyards all over the world.



Bender for Plates up to 18 ft. 1½ in. wide by 2½ in. thick COLD IN PROGRESS.

FOR

RIVETTING, FLANGING, BENDING, STRAIGHTENING, FORGING, STAMPING.

Pumps, Accumulators, &c.

MARINE BOILER MAKERS' TOOLS.

FIELDING & PLATT LTD., GLOUCESTER, ENGLAND.

ESTABLISHED 1868.

NILES-BEMENT-POND CO.

MACHINE TOOLS

For Railroad Shops and General Manufacturing

DUPLEX CONTROL BORER, DRILLER AND MILLER.

May be operated from either side. Every lever and hand wheel shown on the front is duplicated on the other side of machine

Machine Tools for Locomotive, Car and Railroad Repair Shops

LATHES, Driving Wheel: 51 in. to 90 in. swing. Car Wheel. Axle.
WHEEL PRESSES: Capacities, 200 to 600 tons, and to take wheels from 43 in. to 90 in.
CAR WHEEL BORING MACHINES, to take wheels up to 42 in.
AXLE CENTERING AND CUTTING-OFF MACHINES.
WHEEL QUARTERING MACHINES.
STEAM HAMMERS: single and double frame.
STEAM DROP HAMMERS, &c.
CRANES, TRAVELLING CRANES, HOISTS, &c.

Machine Tools for General Manufacturing

LATHES: From 9 in. swing up to meet any requirement
PLANERS: From 30 in. up to meet any requirements.
BORING MILLS: 36 in. swing up to meet any requirements.
SLOTTERS: 6 in. to 92 in. stroke.
DRILLING MACHINES: 24 in. to 60 in. RADIAL: 4 ft., 5 ft., 6 ft., semi and full universal; also heavy duty type up to 10 ft. MULTIPLE SPINDLE: 3, 4, and 6 spindles, in variety of types.
MILLING MACHINES: Built in variety of types and sizes to suit customers requirements.
SHAPERS: Travelling Head. Single or Double, 22 in. and 36 in. stroke.
HORIZONTAL BORING AND DRILLING MACHINES.
HORIZONTAL BORING, DRILLING AND MILLING MACHINES.
CYLINDER BORING MACHINES.

General Offices: 111, Broadway, New York. O 5433 London Office: 25, Victoria Street, S.W.

For Canada: The John Bertram & Sons Co., Ltd., Dundas, Montreal, Toronto, Winnipeg, Vancouver.

TELEGRAMS—WERFCONRAD, HAARLEM, DREDGCRAFT, AVE., LONDON.
CODES—LIEBERS, A B C, 5th Ed, and MOREING & NEAL.
TEL.—CITY, 257.
Agents: MARINE WORKS, Ltd.,

WERF CONRAD, HAARLEM, HOLLAND.

FRIARS HOUSE, 39-41, NEW BROAD STREET, LONDON, E.C. 2.

DREDGING PLANT

OF THE LATEST AND MOST IMPROVED TYPES, OF ALL DESCRIPTIONS, AND UP TO THE LARGEST DIMENSIONS AND CAPABILITIES.

BARGES AND FLATS BUILT IN SECTIONS FOR RE-ERECTION ABROAD.

BUCKET HOPPER AND BARGE-LOADING DREDGERS.

SUCTION PUMP DREDGERS.

COMBINED BUCKET AND PUMP DREDGERS

SUCTION CUTTING DREDGERS for DREDGING CLAY, &c.

One of several Suction Hopper Dredgers built for the Argentine Government.

FLOATING CRANES.

COAL BUNKERING VESSELS.

HOPPER BARGES of any capacity.

SPARE PARTS and RENEWALS supplied.

GOLD AND TIN RECOVERING DREDGERS A Speciality.

7539

DESIGNS, QUOTATIONS, AND ALL DETAILED INFORMATION, BOTH AS TO DREDGING PLANT AND DREDGING GENERALLY, AND UPON ALL QUESTIONS AFFECTING THE RECOVERY OF GOLD, PLATINUM AND TIN, ON APPLICATION.

"MARSHALL"

WRITE FOR OUR LATEST ILLUSTRATED CATALOGUE, No. 1086. MENTION "ENGINEERING."

HUNDREDS OF THESE TRACTORS ARE IN USE FOR INDUSTRIAL, AGRICULTURAL, MUNICIPAL & OTHER SERVICES.

STEAM TRACTORS

TRAILER WAGONS

PATENT ANTI-INCRUSTATION FIREBOX SUPPLIED, NO EXTRA COST.

FIXED BODIES, END TIPPING & SIDE TIPPING, TO MEET ALL USUAL REQUIREMENTS.

7979

MARSHALL, SONS & Co., LTD., GAINSBOROUGH.

The Right Valve for every Service

WE were among the pioneers of the valve-making industry in this country, and have ever since specialised in valves of the highest class.

By our policy of continual improvement and adaptation of designs to actual service requirements we are in a position to offer the right valve for every purpose.

We make valves in every conceivable variety, and can supply you with anything from a ½-in. Cock to a Valve 96-in. bore.

May we serve you?

J. Blakeborough & Sons Ltd

BRIGHOUSE, ENGLAND.

7448

THE BLACKSTONE OIL ENGINE.

Stationary Type.
For Crude Oil ... 9½ to 300 B.HP.
For Refined Petroleum 1½ „ 75 B.HP.

Portable Type.
For Crude Oil ... 9½ „ 45 B.HP.
For Refined Petroleum 1½ „ 35 B.HP.

BRANCHES :—

LONDON: 81, Cannon Street, E.C.

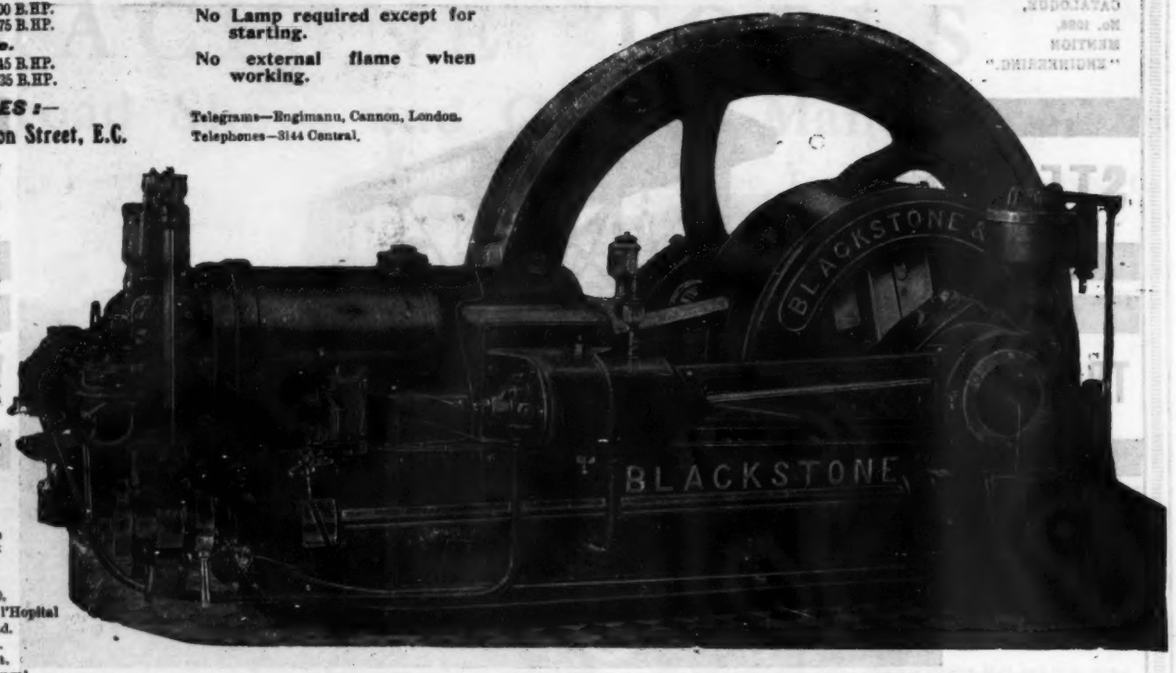
ADELAIDE ...	61-63, Hindley Street.
ALEXANDRIA .	Rue du la Gare du Caire.
BOMBAY. ...	Marshall's Buildings, Ballard Road.
BUENOS AIRES	333 Calle Peru 335
CAIRO	Rue Bab-el-Hadeed.
CALCUTTA ...	86, Clive Street, and 25, Strand.
CHRISTCHURCH, N.Z.	South Belt.
DUBLIN ...	Dickies Warehouse, South Dock Street.
EAST LONDON S. Africa ...	Cambridge Street.
GERALDTON, W.A.	Marine Terrace.
GLASGOW ...	Paton Street.
LAHORE ...	Napier Road, Anarkalli.
MADRAS ...	9, Second Line Beach (Post Box 141 Madras E).
MELBOURNE ...	385, Bourke St.
MILAN	Via Palermo 8-10.
PARIS	26, Boulevard de l'Hopital
SHANGHAI ...	20, Foochow Road.
SYDNEY ...	352, Kent Street.
THE HAGUE ...	5, Verhulststraat.
TUNIS	109, Rue de Portugal.

Starts in 4 minutes.

No Lamp required except for starting.

No external flame when working.

Telegrams—Engimanu, Cannon, London.
Telephones—3144 Central.



From a Photograph of the MCG 75 B.HP. "Blackstone" Fuel Oil Engine.

ESTIMATES & FULL PARTICULARS POST FREE. Telegrams—"Blackstone, Stamford." Telephones—Nos. 307 and 308 (Two L. e.). Codes used—A1, ABC (4th and 5th Editions), Lieber's, Engineering. 7366

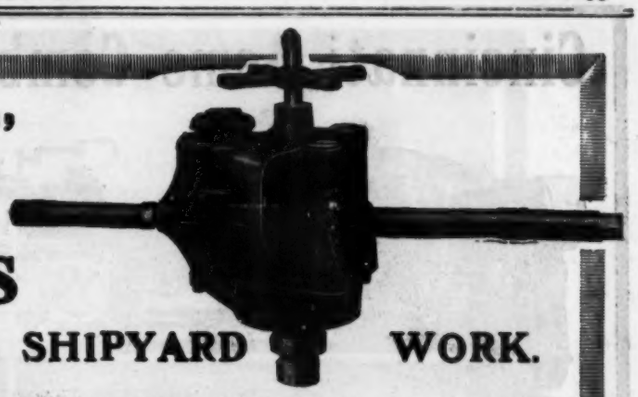
BLACKSTONE & CO., Ld., Stamford, England.

PARTINGTON STEEL & IRON COMPANY Ltd

"LITTLE DAVID"

PNEUMATIC TOOLS

For CONSTRUCTION, SHOP and SHIPYARD WORK.



YOU will find in the use of "Little David" Drills, Grinders, Rivetters, Chippers, &c., a remarkable degree of satisfaction. High efficiency is combined with extremely simple design. They can be taken down and assembled in the field—no vice or elaborate equipment needed.

There's a tool for every duty, and all are described in the "Little David" Catalogue. Shall we send a copy?

INGERSOLL RAND

CO. (Inc. in U.S.A.)

165, Queen Victoria Street,

LONDON, E.C.

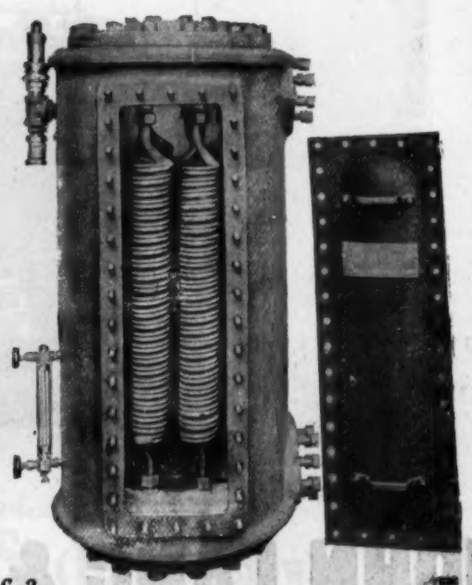
NEW YORK: 11, Broadway.

SALES REPRESENTATIVES FOR U.K.: JOHN MACDONALD & SON, Ltd., Watt Street, Maryhill, GLASGOW.

OFFICES: the world over.

Marine Auxiliaries

FEED WATER HEATERS.
FUEL OIL HEATERS.
COMPLETE DISTILLING PLANTS.
FILTERS.
STRAINERS.
LUBRICATING OIL COOLERS.



Reilly Type "D" Heater.

The Griscom-Russell Co.,

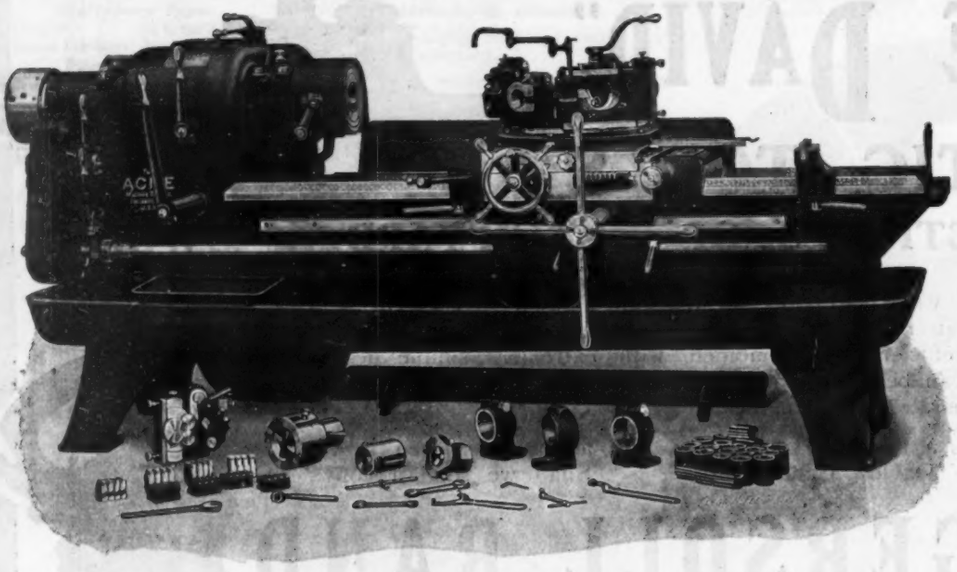
95, West Street, New York, U.S.A.

Cable Address: "Grispen, New York."

For England: W. Christie & Grey, Ltd., 4, Lloyd's Avenue, London, E.C. 3.

Telegraphic Address: "TYPHAGITOR." Telephone: AVENUE 1321.

Cincinnati Acme Combination Flat Turret Lathes.



3¼ in. by 36 in. Cincinnati Acme Combination Flat Turret Lathe.
WITH EQUIPMENT FOR BAR WORK.

With Geared Head.
Chucking Capacity, height of Centres 11 in.
3¼ in. by 36 in. Bar Capacity.

With Cone Head and Friction Back Gears.
Chucking Capacity, height of Centres 10 in.
2¼ in. by 26 in. Bar Capacity.

With Bar, Chucking or Both Equipments.

DELIVERY FROM STOCK.

Sole Agents: 7085

Telegrams:—"VIKING, BIRMINGHAM."

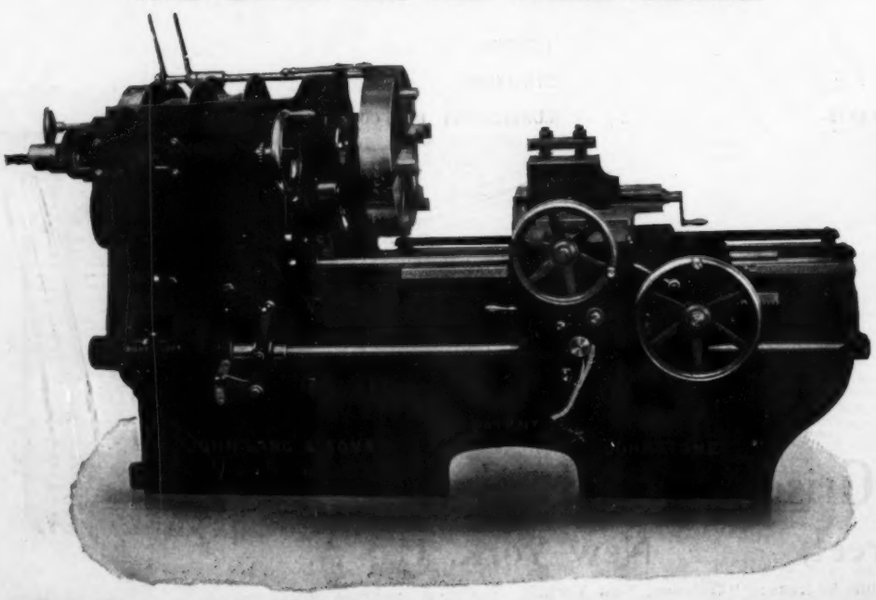
George H. Alexander, Coleshill Street, Birmingham.

LONDON OFFICES:—57/9, Long Acre, London, W.C. 2.

WHAT IS YOUR OPINION OF A LATHE?

When the spindle speed automatically increases as the tool travels towards the centre]
When the correct speed can be obtained for any diameter.
When the guiding surface of the bed is covered.
When the speed variator is ONE hand-wheel.
When a counter motion is unnecessary.

THIS LATHE HAS ALL THESE CLAIMS.



JOHN LANG & SONS, LATHE MANUFACTURERS.

JOHNSTONE, near GLASGOW. 6422

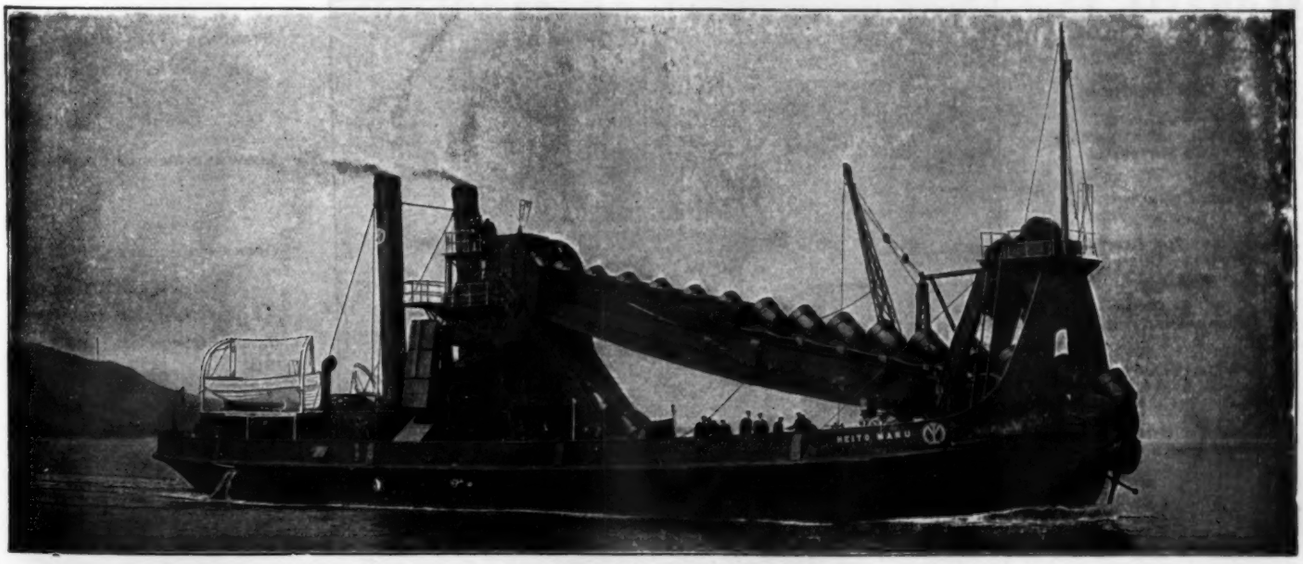
JOHN I. THORNYCROFT & Co LIMITED, 10, Grosvenor Place, S.W.1.
BASINGSTOKE AND SOUTHAMPTON.

DREDGING PLANT

Up to the Largest Dimensions and Capabilities.

Grand Prize at London Exhibition, 1909.
Gold Medal, Japan-British Exhibition, 1914.

Bow and Stern Well Centre and Side Ladder Bucket Barge Loading and Hopper-Dredgers, Suction Dredgers, Hydraulic and Mechanical Agitators, Discharge Pipes and Pontoons, Hopper Barges, Sewage Steamers, Caissons, Tugs, Ferries, Paddle and Screw Steamers.



Delivered Complete or Shipped in Sections. ***Spare Gear and Renewals Supplied.***

FERGUSON BROTHERS (Port Glasgow), LTD.

SHIPBUILDERS AND ENGINEERS.

ON WAR OFFICE AND ADMIRALTY LISTS. ***NEWARK WORKS, PORT GLASGOW.*** *Tels. Address: DREDGER, PORT GLASGOW.*

STRUCTURAL STEEL WORK.

JOHN BOOTH & SONS, BOLTON.

6793

RAILWAY BRIDGE OVER CANAL.

DIESEL OIL ENGINES

BRITISH MADE.

SPECIAL FEATURES.

ROBUST CONSTRUCTION.

HIGHEST-CLASS WORKMANSHIP AND MATERIALS.

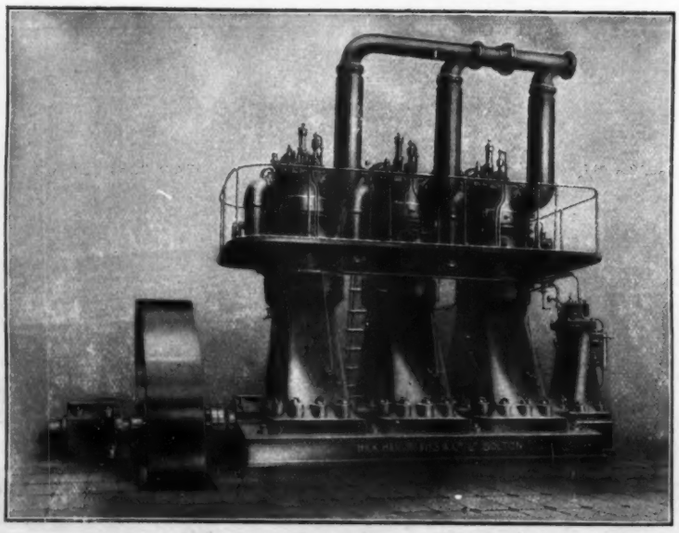
LOW FUEL CONSUMPTION.

RELIABILITY FOR CONTINUOUS HEAVY DUTY.

EASE OF STARTING AND MINIMUM OF ATTENTION.

ACCESSIBILITY AND INTERCHANGEABILITY.

ABILITY TO BURN LOW-GRADE FUELS.



STANDARD SIZES RANGING FROM 80 TO 1020 B.HP.

SLOW AND MEDIUM SPEEDS.

OPEN AND ENCLOSED TYPES.

MOST ECONOMICAL PRIME MOVER FOR ELECTRIC POWER SUPPLY, OIL AND WATER PUMPING AND GENERAL PURPOSES.

Standard 3-Cylinder 510 B.HP. Open Type Engine.

HICK, HARGREAVES & CO., LTD.,

BOLTON, ENGLAND.

MANUFACTURERS OF HIGH EFFICIENCY CORLISS, DROP VALVE, AND UNIFLOW STEAM ENGINES—DIESEL-TYPE OIL ENGINES—CONDENSING PLANTS WITH HICK-BREGUET EJECTAIR—STEAM AND ELECTRICALLY-DRIVEN WINDING ENGINES—MILL GEARING.

7843

TANGYES OIL ENGINES.

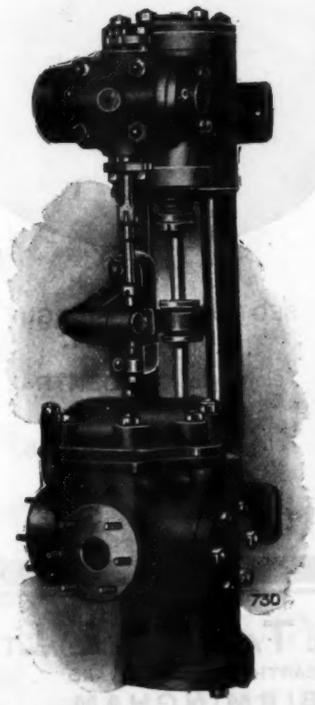
ENGINES CAN BE DELIVERED FROM STOCK.

TANGYES LTD., BIRMINGHAM.

3050 No. 300 B.

WORTHINGTON-SIMPSON

VERTICAL SIMPLEX FEED PUMP



Specially Designed for

MARINE SERVICE

Small Floor Space - - Simplicity
Adaptability - Few Working Parts

DELIVERIES from STOCK.
Apply for Leaflet. — 7046

WORHTINGTON-SIMPSON LTD

Queen's House, Kingsway, London, W.C. 2.

Telephone: 3048—49—50 HOLBORN.

Works: NEWARK-ON-TRENT.

Telegrams: "PUMPING, WESTCENT, LONDON."

OVER 30 YEARS' EXPERIENCE
IN THE DESIGN & MANUFACTURE OF
CRANE MOTORS FOR ALL CLASSES OF HEAVY WORK

Notes on The ELECTRIC DRIVING OF Deck Winches Warping Capstans Anchor Windlasses and Steering Gear By W. M. Scott, M.I.E.E. Laurence Scott & Co. Ltd. Norwich ESTABLISHED 1883

Booklet Free on application.

Ball-bearing Crane Motor.

Electric Motors 1914 Third Edition Laurence, Scott and Co. Ltd. Norwich ESTABLISHED 1883

Booklet Free on application.

Established · 1883 ·

LAURENCE, SCOTT & Co. LTD.

TEL. ADD: GOTHIC NORWICH · NORWICH · 'PHONE Nos. 1362 & 1363

7749

TAYLOR CHUCKS

THESE **CHUCKS** WILL STAND UP TO **HIGH-SPEED STEEL** AND RUN **TRUE** LONGER THAN ANY OTHER **CHUCK** ON THE MARKET.

3 & 4 JAWS FOR ENGINEERS AND 2 JAWS FOR BRASSWORKERS.

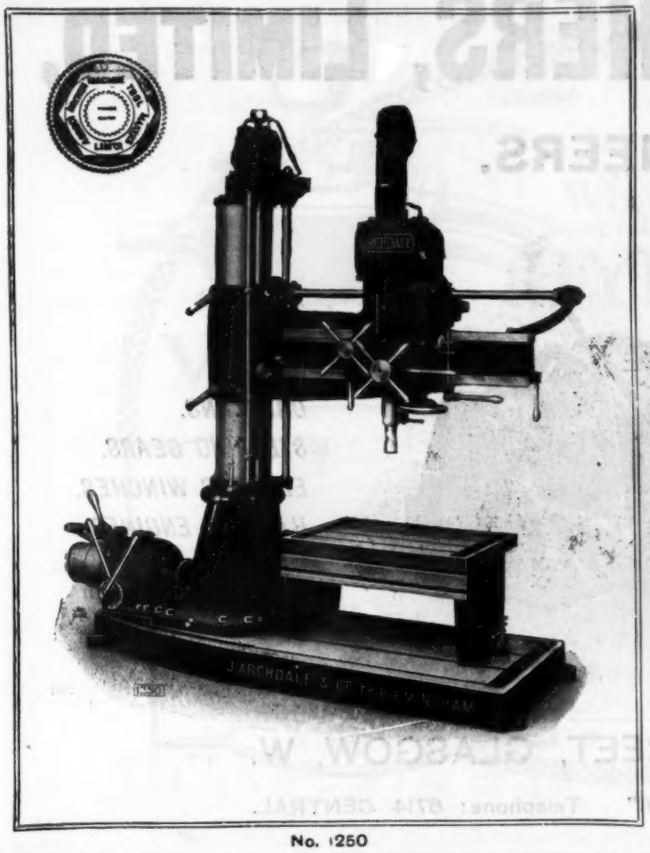
SECTION 6 CATALOGUE ON REQUEST.

Telephone No.: CENTRAL 6373 (3 lines).

Telegrams: "LATHES," BIRMINGHAM."

7301

CHAS. TAYLOR (BIRM.) LTD.
BARTHOLOMEW SQUARE,
BIRMINGHAM.



No. 1250

ARCHDALE

RADIAL
DRILLING MACHINES

From 3½ ft. to 4ft. 6 in. Radius.

No. 1250

THREE SIZES - 3½ ft., 4 ft. and 4 ft. 6 in. Radius.

18 SPINDLE SPEEDS

Spindle instantly reversed at any speed by lever on saddle.

Improved Locks to saddle and arm.

4 RATES GEARED FEED

Double Gear instantly engaged by lever on saddle.

Automatic Stop Motion to spindle.

DRILLS up to 2 in. DIA. in M.S.

6905

J. ARCHDALE & CO., Ltd.

Ledsam Street, BIRMINGHAM.

— THE —

SOLUTION OF PRODUCTION DIFFICULTIES

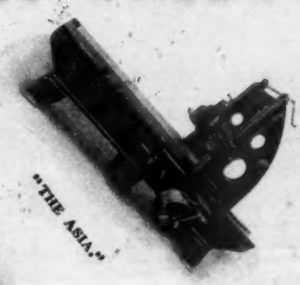
IS

HIGH-CLASS MACHINE TOOLS

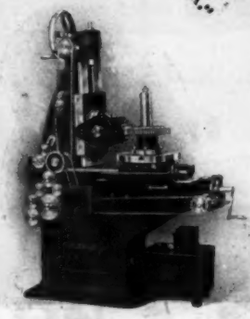
Made by

THE DANISH MACHINE CO., LTD., COPENHAGEN.

"THE JUTLANDIA."



"THE ASIA."



"THE SELANDIA."

PLACE YOUR ORDER NOW.

6 in. to 10 in. Centre, Self-Acting, Sliding, Surfacing and Screw-Cutting Precision Lathes.

6 in. to 10 in. Precision High-Speed Lathes.

"THE GIANT" Precision High-Speed Turret Lathe.

Planing Machines—Crank-Shaping Machines—Lathe Chucks.

Automatic Wheel-Cutting Machines—Keyway Cutting Machines.

Wall—Radial—Drilling Machines.

DELIVERY—IMMEDIATE FROM STOCK FOR MOST STYLES.

For ILLUSTRATED CATALOGUES and full particulars, apply—

ENGLISH REPRESENTATIVES: 8135

COLLEY ENGINEERING & MACHINERY CO. (MACHINE TOOL DEPT.),

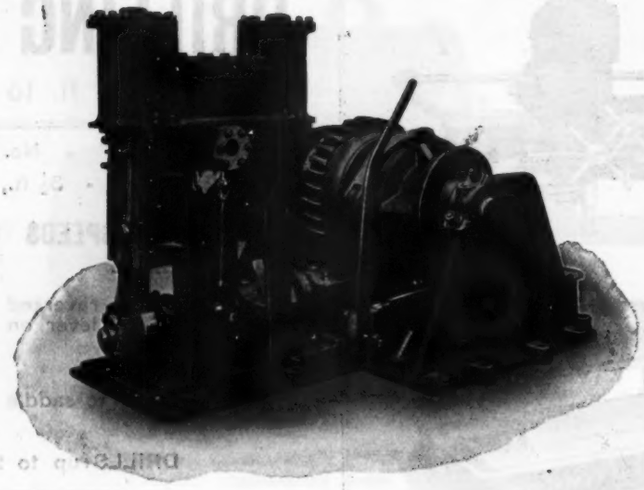
LONDON — PARIS — NEW YORK — CALCUTTA

Head Office: "CLUN HOUSE," 17, SURREY ST., STRAND, LONDON, W.C. 2.

TELEGRAMS: NUCLEOLUS, 'PHONE, LONDON.
TELEPHONE: CITY 2081 (3 Lines).

NAPIER BROTHERS, LIMITED,

ENGINEERS.



WINDLASSES
From ⅜ in. to 4 in. CABLES.

CAPSTANS.
STEERING GEARS.
ELECTRIC WINCHES.
HAULING ENGINES.

7847

130, HYDEPARK STREET, GLASGOW, W.

Telegrams: "WINDLASS, GLASGOW." Telephone: 6714 CENTRAL.

WATER TURBINES.

PIPE LINES.

GOVERNORS.

HYDRO ELECTRIC POWER SCHEMES.

HIGH MEDIUM & LOW PRESSURE CENTRIFUGAL PUMPS for all purposes.

8063

MOUNT LYELL MINING & RLY. CO., TASMANIA (1st Contract under Construction).
Five 2000 HP. Water Turbine Units Installed.

BOVING & CO., LTD.,

56, KINGSWAY, LONDON, W.C.2
Telegrams—"JENORTEN PHONE, LONDON."
Telephone—HOLBORN 6420.
Works—STOKE-ON-TRENT.

Branches and Agents:— MANCHESTER — R. Millet, 30, Cross Street. GLASGOW—T. C. Leonard, 50, Wellington Street. NEWCASTLE-ON-TYNE—J. Straker Wilson, 3, St. Nicholas Buildings. PARIS—68, Rue Caumartin. JAPAN—No. 1, Yaesu Cho, 1, Chome Tokio. Australasia—Bank of N.S.W. Chambers, Lambton Quay, Wellington. S. AMERICA—With, Walter & Co., 65, Rua General Camara, Rio-de-Janeiro. CANADA—Boving Hydraulic & Eng. Co., Lindsay, Ont.

B.End.
The
WILLIAMS-JANNEY
(MANUFACTURERS VICKERS LIMITED.)
HYDRAULIC
VARIABLE SPEED GEARS
for—
SHIPS STEERING GEARS, CRANES,
CAPSTANS, WINDLASSES, WINCHES &
HOISTING APPLIANCES; MACHINE TOOLS.
Suitable for any purpose where it is desired to convert a constant speed in one direction into an infinitely variable speed in either direction and to develope a high starting torque.
TYPE C.
These Machines are made in 9 Sizes capable of transmitting from 2 to 200 H.P.
For full particulars apply to
The VARIABLE SPEED GEAR LIMITED.
Broadway Court
LONDON, S.W.1.
A.End.
7498
END

Clayton

STEAM MOTOR WAGONS.
STEAM TRACTORS
CHAIN RAIL TRACTORS.
ROAD LOCOMOTIVES.
TIPPING WAGONS & TRAILERS.
RAILWAY WAGONS.
PASSENGER COACHES.
ALSO FORGINGS, STAMPINGS AND PRESSINGS.

Write for Catalogues and Particulars from

CLAYTON & SHUTTLEWORTH, LTD.,
LINCOLN, ENGLAND.

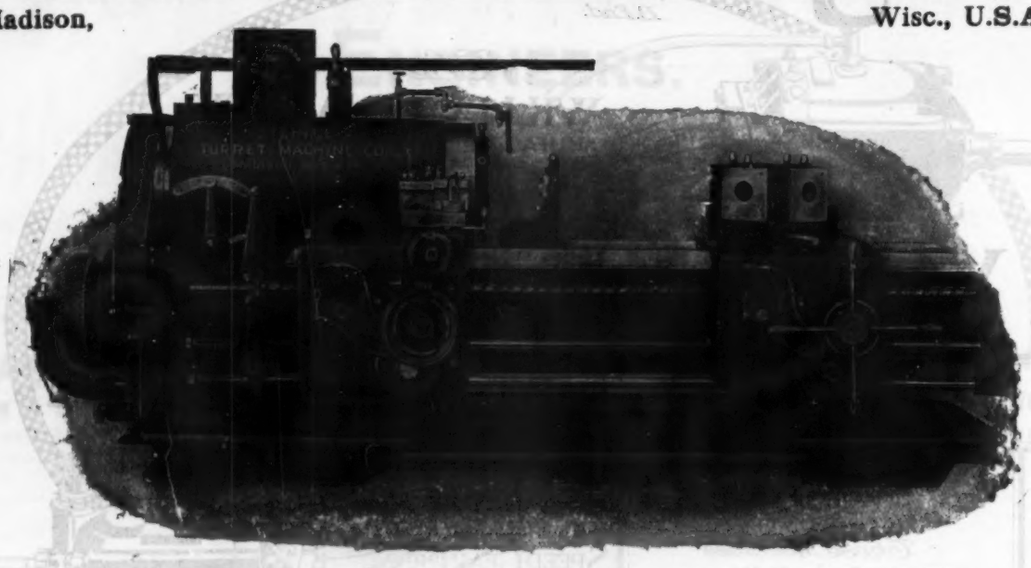
7330

TELEGRAMS: CLAYTONS, LINCOLN. ESTABLISHED 1842. TELEPHONES 42.
Also at Princes Chambers, Corporation Street, Birmingham.

A GENERAL PURPOSE TURRET LATHE

STEINLE TURRET MACHINE COMPANY,

Madison, Wisc., U.S.A.



7329

This Lathe is designed to give continued satisfaction, and will stand up under the most trying conditions demanded by continued rapid production.

Write for complete information—Illustrated Catalogue and Prices.

LEO C. STEINLE,

53, VICTORIA STREET, LONDON, S.W.

SPECIAL STEEL

FOR ALL PURPOSES

MYRRYS TRADE MARK

BULLET PROOF PLATES

MINING & TOOL STEEL

7314

Send your enquiries to:

THE MIRIS STEEL COMPANY, LTD.

KING'S HOUSE, KING STREET, LONDON, E.C.

Telegrams: "Mirissimus, Cent." Telephone: City 3329.

Works: Nursery Street, Sheffield. Telegrams: "Mirissimus." 'Phone: Central 594, 595.

AVERY'S BRINELL HARDNESS TESTER

AVERY

The only Brinell Hardness Tester embodying the weighing lever knife-edge and bearing principle.

Sensitive to increments of load of 1 kilo.

Calibration obtainable by a dead load of 3000 kilos.

No calculated load is employed.

"Brinelling" on an Avery Machine ensures a consistent accuracy unobtainable with any other design.

7983

W. & T. AVERY LTD
SOHO FOUNDRY
BIRMINGHAM, ENGLAND.

Ad.369

VICKERS-PETTER OIL ENGINES
FOR
LAND & SEA

A Letter received from a user of Vickers-Petter Oil Engines:—

MOTORSHIP "HIBERNIA,"
360 tons cargo, equipped with
152 B.H.P. Vickers-Petter Marine Oil Engine.

ARTHUR TATE & CO. LTD.
EXPORTERS OF COAL, COKE, BRICKS & SALT.
NEWCASTLE-ON-TYNE.

24th October, 1 19.

Dear Sirs,

Referring to the 152 B.H.P. Internal Combustion Engine supplied by Messrs. Vickers-Petters and installed into our iron vessel "Hibernia," 360 tons cargo, we have much pleasure in advising you that up to the present, namely, after the fourth voyage to France with coal cargoes, the engine has been proved to be of first-class workmanship and has run smoothly the whole time.

We are delighted with it and consider that it surpasses any engine we have yet installed in our ships, numbering a dozen. The good results of this engine prove that in Britain we are on a par with, and even can keep ahead of, our competitors in other countries in building this class of engine.

The "Hibernia" made 9½ knots light ship coming up from the Humber to the Tyne, and regularly does over 8 knots loaded between here and France. Her average passage with cargo from Tyne or Blyth to Calais has been about 38 hours, and the Captain boasts that he has beaten half of the steam driven coasting vessels in the trade.

We trust that the other engines we have ordered from you namely, the 200's and 152's will prove as satisfactory, when we shall have nothing to complain of.

The fuel consumption is lower than that of any other make of engine.

Yours faithfully,
ARTHUR TATE & COMPANY LIMITED,
Arthur Tate,
Director.

Write for Catalogues to:—

VICKERS-PETTERS LIMITED,

Marine Department: 73, QUEEN VICTORIA STREET, LONDON, E.C. 4. **Works: IPSWICH, ENGLAND.**

8056

FISHER & LUDLOW LTD.

Telephones - - - 413 and 414 MIDLAND.

Heavy and Light Stamped and Pressed Metalwork of all descriptions. Specialists in Motor and Aero Stampings and Pressings. Aero Engine Exhausts and Tanks. We have Power Presses giving up to 1000 tons pressure on the dies.

ALBION WORKS, REA ST. BIRMINGHAM.

7563

On Admiralty, Lloyds' Registry and Crown Agents for the Colonies Lists.

Telephone:
44 DARLASTON.
1361 VICTORIA.

Telegrams:
"STEEL, DARLASTON."
"SAEPIUS, VIC, LONDON."

STEEL CASTINGS

FROM

2 LBS. to 20 TONS.

Head Office:
JAMES BRIDGE STEEL WORKS, WEDNESBURY.

London Office:
50, QUEEN ANNE'S GATE, WESTMINSTER, S.W. 1.

Branch Offices:
134, DEANSGATE, MANCHESTER.
19, WATERLOO ROAD, NEWPORT, MON.
143, WEST REGENT STREET, GLASGOW.

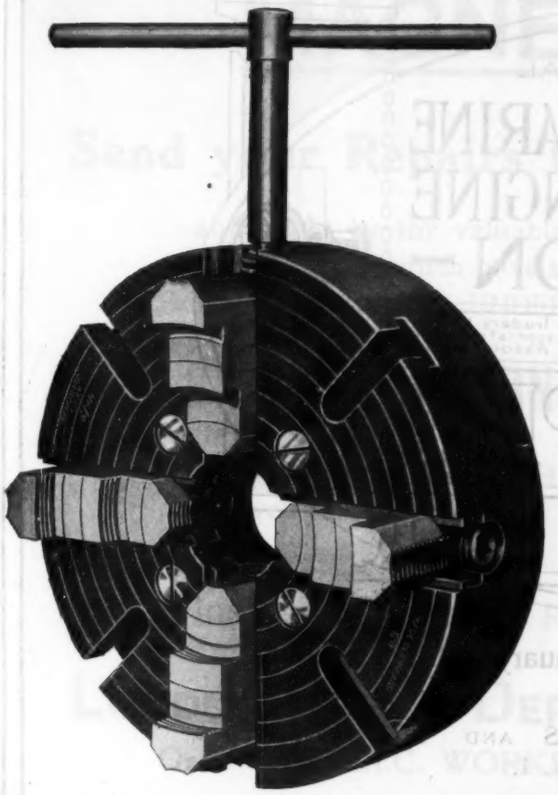
THE quality of our Castings is the outcome of over Forty Years' Experience. We can supply you from Siemen's Open Hearth, Tropenas, or Electric Furnaces. An up-to-date plant is at your disposal for Castings of all descriptions, Sandblasting, Annealing and Fettling being carried out by modern methods. A separate repetition foundry is capable of dealing promptly with large numbers of castings. *Give us the privilege of quoting you.*

7512

F. H. LLOYD & CO., LTD

JAMES BRIDGE STEEL WORKS
NEAR
WEDNESBURY.

CONQUEROR four-jaw Independent (Reversible-jaw) LATHE CHUCKS



:: MADE IN ENGLAND. ::
INTERCHANGEABLE PARTS.

MADE by the Most Modern Mass Production on the Best Procurable Machinery of the Best Possible Materials, and by the Most Skilled British Workmen!

BUY the Peerless **CONQUEROR** Chuck and show your appreciation of British Initiative and Skill.

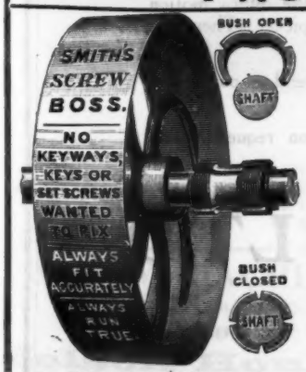
7643

Home and Export Sole Selling Agents:—

GEORGE HATCH, LTD., 3, 20, & 21, QUEENHITHE, LONDON, E.C. 4.

SMITH'S PATENTS FOR THE TRANSMISSION OF POWER

FACTORY EQUIPMENT a Speciality.



Cast Iron Pulleys.

SMITH'S Swivel Adjustable SELF OILING BEARINGS, Hangers, Wall Brackets, Standards, Wall Boxes, SMITH'S GRIP COUPLINGS. Turned Steel Shafting, Collars, And all Accessories for POWER TRANSMISSION.

Complete Catalogue of SHAFTING, FITTINGS and PULLEYS on application.

SMITH & GRACE, LTD.,
THRAPSTON.

LONDON: 35, Queen Victoria Street, E.C.

6761

'PHONE—London: 9531 City. Works: 19 Thrapston.

SWIVEL, ADJUSTABLE, SELF-OILING

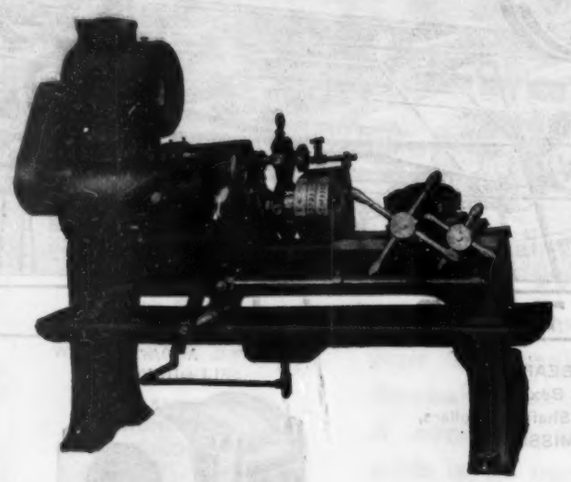
PLUMMER BLOCKS.

THE INTERNATIONAL
MOTOR BOAT & MARINE
& STATIONARY ENGINE
— EXHIBITION —
Organized by The Society of Motor Manufacturers & Traders Ltd. in collaboration with The Ship & Boat Builders Association, Ltd. & The British Gas & Oil Engine Manufacturers Association.
OLYMPIA
MAR: 12th–20th 1920

Space Application Lists Close January 5th, 1920

Full Particulars from The Exhibition Manager—
SOCIETY OF MOTOR MANUFACTURERS AND TRADERS, LTD.,
83. PALL MALL, S.W. 1.

Heap's Automatic Screwing Machines



Arranged for Direct Motor Drive.

These machines are made in all sizes with Single and Double Heads.

When desired they can be fitted with an All-Gear Head instead of the usual Cone Pulley. The drive can then be by Electric Motor as illustrated, or by Constant Speed Belt.

All these machines are fitted with our Patent Steel Head, which is the most simple and only mechanical Die-head on the market. Springs, with their attendant troubles or other delicate mechanisms, which can get clogged with dirt and the swarf inseparable from a Screwing Machine, do not enter into its construction in any way.

The Die-head opens automatically and the return motion of the carriage closes it ready for the next piece. There are no other levers to set.

If you have threading work to deal with send us particulars and we will offer you a suitable machine.

Copy of Catalogue will be posted free on request to all responsible firms.

7518

JOSHUA HEAP & CO., LTD.,

ASHTON-UNDER-LYNE, ENGLAND.

MAGNETO REPAIRS

Send your Repairs to a Firm that make MAGNETOS

and profit by the valuable experience gained in making and repairing MAGNETOS which have stood the severest of all tests on AERO, TANK and other Engines UNDER WAR CONDITIONS.

THE BRITISH LIGHTING & IGNITION CO., LTD (Proprietors: VICKERS LTD.)

Makers of the famous B.L.I.C. MAGNETOS, specialise in Repairs to all well-known makes of Ignition Equipment.

MAGNETOS and COILS for REPAIRS, Cars for ADJUSTMENT to the IGNITION SYSTEM and Re-Wiring, we shall be pleased to receive at our

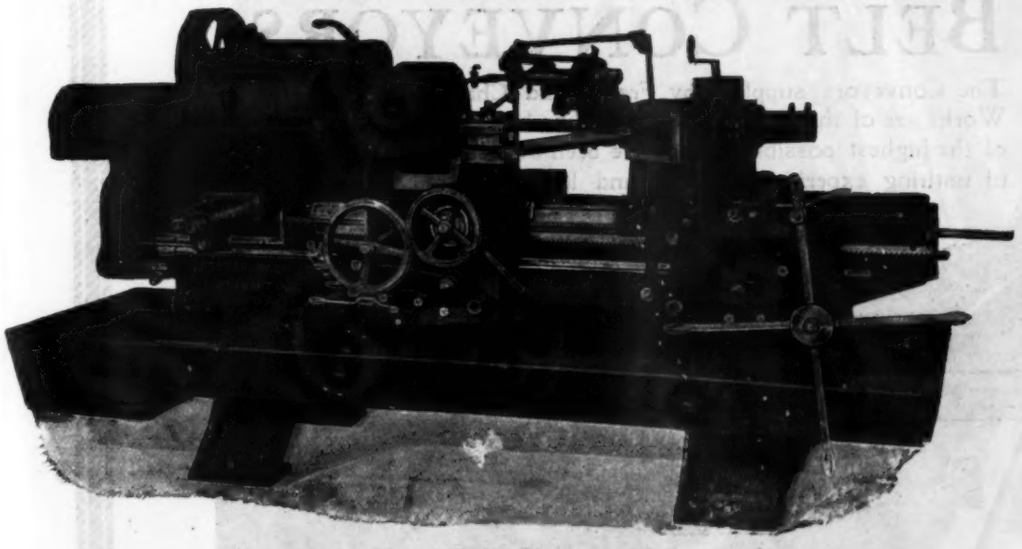
LONDON REPAIR DEPOT: 200-203, Tottenham Court Road, W. 1.

Or at the B.L.I.C. WORKS, Cheston Road, ASTON, BIRMINGHAM. 7321

Sole Agents for

FOSTER UNIVERSAL TURRET LATHES

For Manufacturing in Large Quantities or Handling a Variety of Work.



FEATURES:

Covenience of Operation.

Ample Power.

Large Working Range.

Absolute Control of Work and Tools

Wide and Well Balanced Speed and Feed Ranges, affording ideal speed and feed combinations essential to large output.

Powerful Drive.

Several Cutters at work simultaneously.

Eleven Tools, several carrying Multiple Cutters. can be mounted on the two tool-carrying units at one setting.

3½ in. Size.

Capacity.	Swing Over Bed.	Swing Over Carriage Guides.	Swing Over Cross Slides.
2 in. } IN STOCK.	15½ in.	14 in.	8 in.
3½ in }	22 in.	20 in.	13½ in.
4½ in.	28 in.	26 in.	18½ in.

SCREW MACHINES, 7/16 in. to 1 1/16 in. capacity, *IN STOCK.*

SELSON

ENGINEERING CO., LTD. 2481

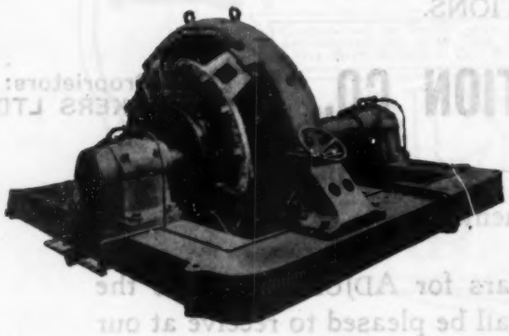
GREENLEE FLAT-TURRET LATHES, 2½ in. by 26 in. and 3½ in. by 40 in. *IN STOCK.*

Selson House, 83/5, Queen Victoria St, London, E.C. 4.

G.E.C. Electrical Plant

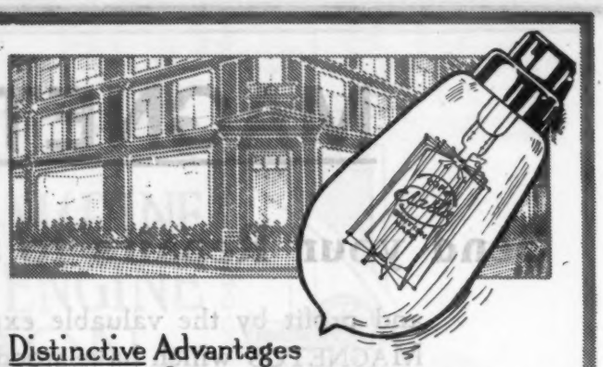
The unsurpassed manufacturing facilities of the General Electric Company's Works at Witton, near Birmingham, and its association with Fraser & Chalmers' Engineering Works, Erith, Kent, enable complete contracts to be undertaken for Electrical Plant (Lighting, Power and Traction).

Enquiries Invited.



The General Electric Co., Ltd.,
Head Office: 67, QUEEN VICTORIA ST., LONDON, E.C.4.
Engineering Works: WITTON, Nr. BIRMINGHAM.
Fraser & Chalmers' Engineering Works, Erith, Kent.

7972



Distinctive Advantages of Pope's Elasta Lamps

ENTIRELY BRITISH MADE.

Licensed under British Patents No. 21513/06, 23499/09 and others.

ECONOMY.

Quantity users of Electric lamps will find it very materially to their advantage to use
"POPE" ELASTA DRAWN WIRE LAMPS
on account of their extraordinary low current consumption and exceptionally long life.
Many of the largest Factories, Shops, Theatres, Hotels, etc., use them entirely on this account.

ONCE USED ALWAYS USED.

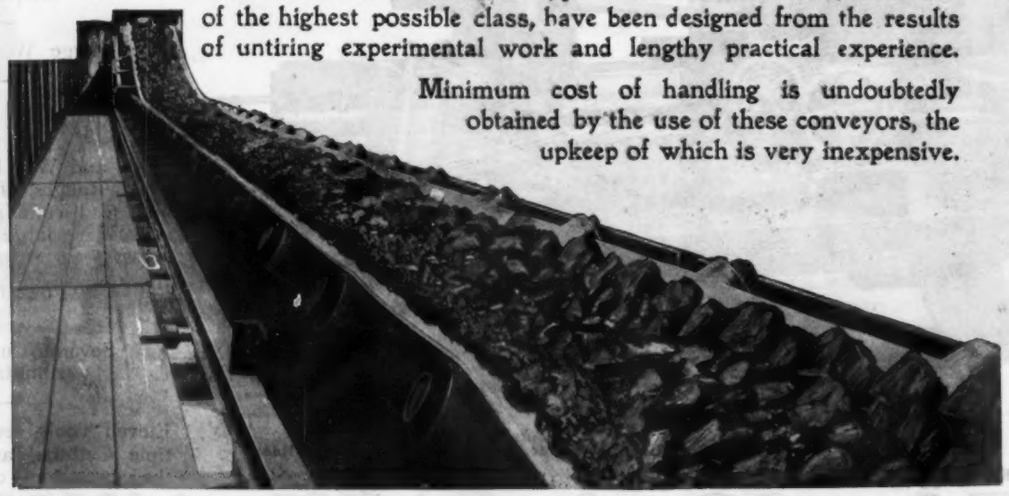
IMMEDIATE DELIVERIES
can now be effected.

POPE'S ELECTRIC LAMP CO., LTD.
Head Office and Works, Hythe Rd., Willesden, N.W. 10.
Telephones: Willesden 1170; Willesden 1244. Telegrams: "Planetary 'Phone, London."

BELT CONVEYORS

The Conveyors supplied by Fraser and Chalmers Engineering Works are of the rubber belt type. The belt and idlers, which are of the highest possible class, have been designed from the results of untiring experimental work and lengthy practical experience.

Minimum cost of handling is undoubtedly obtained by the use of these conveyors, the upkeep of which is very inexpensive.



FRASER & CHALMERS ENGINEERING WORKS

PROPRIETORS: THE GENERAL ELECTRIC CO. LTD.

ERITH, KENT

LONDON OFFICE
67 QUEEN VICTORIA ST. E.C.4

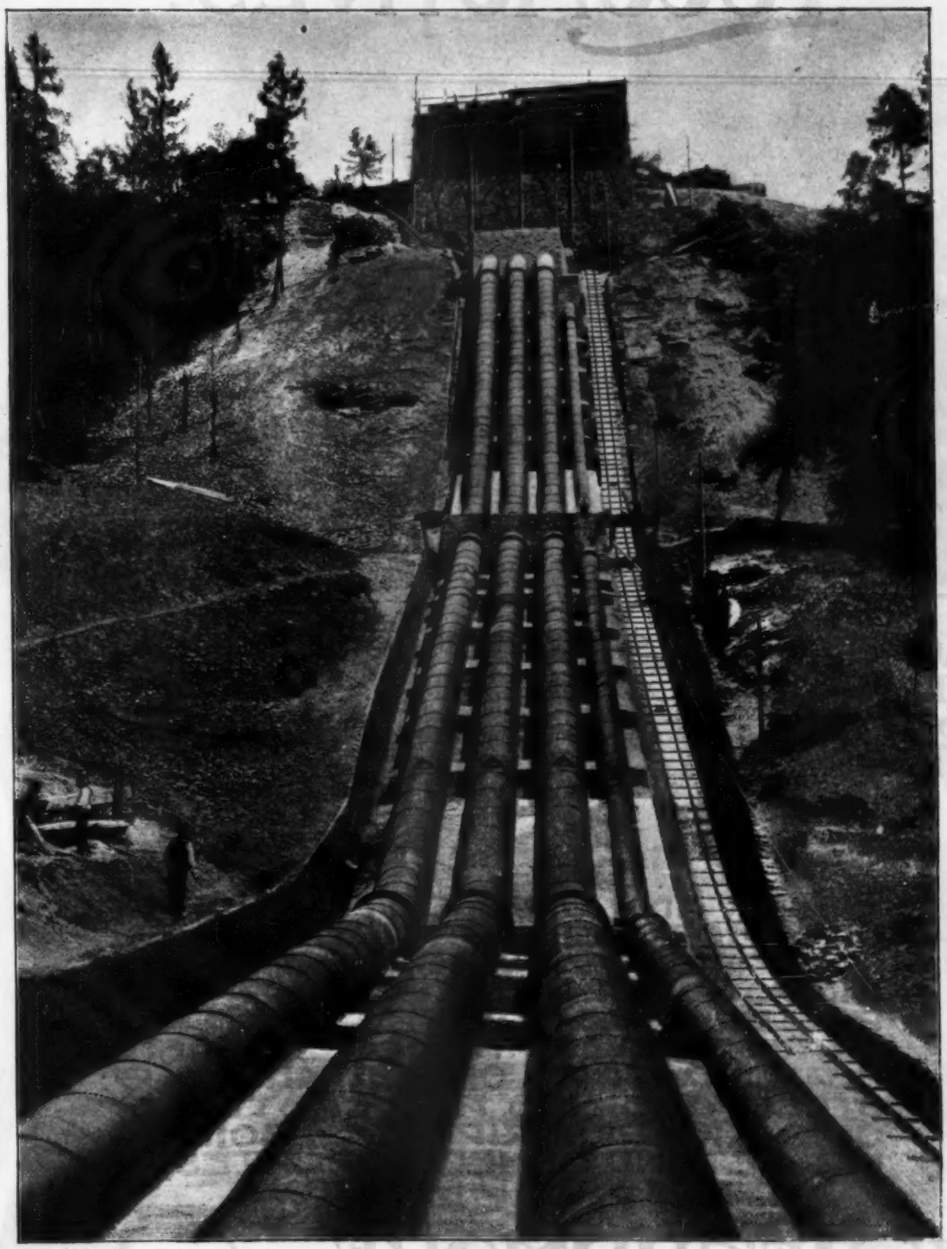
Tubi-Togni, Ltd., Brescia.

WORKS IN BRESCIA AND COGOLETO (ITALY).

Pipes and Tubes

Of Iron and Steel Plates, Welded or Riveted, of all sizes and for every pressure.

500 Plants performed with a total power of 1,200,000 HP. and the highest waterfalls in the world.



GROSSOTTO-VALTELLINA HYDRO-ELECTRIC PLANT FOR THE CITY OF MILANO.
Diameter of Supply Pipes: 1100/1500 mm. Head: 316 m. Power developed: 40,000 HP.

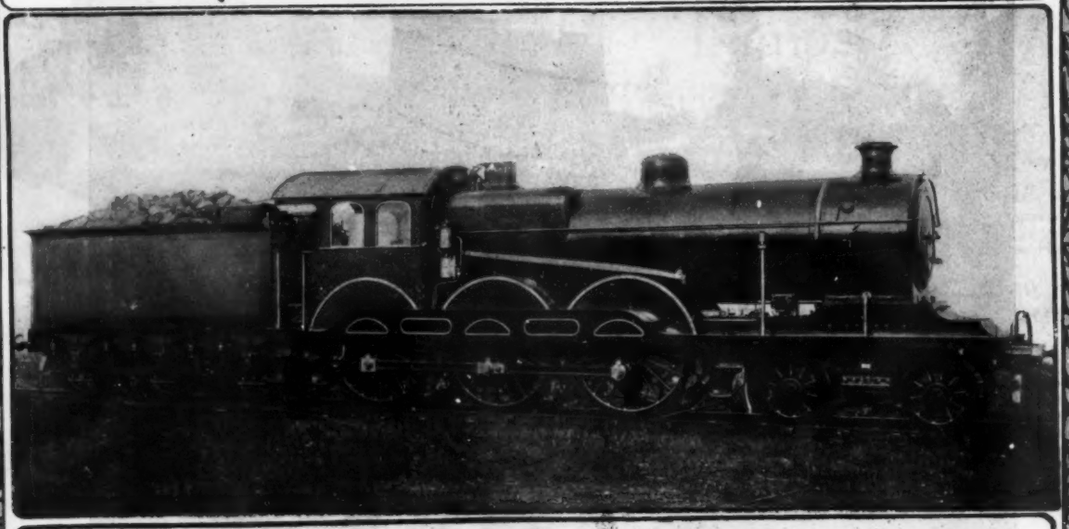
Metallic Dams. Grates. Safety Apparatus. Valves.

Secundary Parts for Water Pipings.

8146

STEAM ELECTRIC PETROL

BEARDMORE LOCOMOTIVES.



LOCOMOTIVES BUILT OF ANY VARIETY OR FOR ANY CONDITION OF SERVICE · STEAM · PETROL · ELECTRIC MAIN-LINE OR NARROW-GAUGE

SIEMENS-MARTIN OPEN-HEARTH ACID-STEEL CRANK AND STRAIGHT AXLES FOR LOCOMOTIVES · STRAIGHT AXLES FOR CARRIAGES WAGONS AND ALL KINDS OF ROLLING-STOCK · CAST & ROLLED-STEEL WHEEL-CENTRES TYRES & AXLES FINISHED COMPLETE FLANGED WORK OF ALL KINDS & STEEL FORGINGS AND CASTINGS OF EVERY DESCRIPTION · BOILER · FRAME AND GENERAL PLATES & BARS AND SECTIONS.

WM. BEARDMORE & CO. LTD.

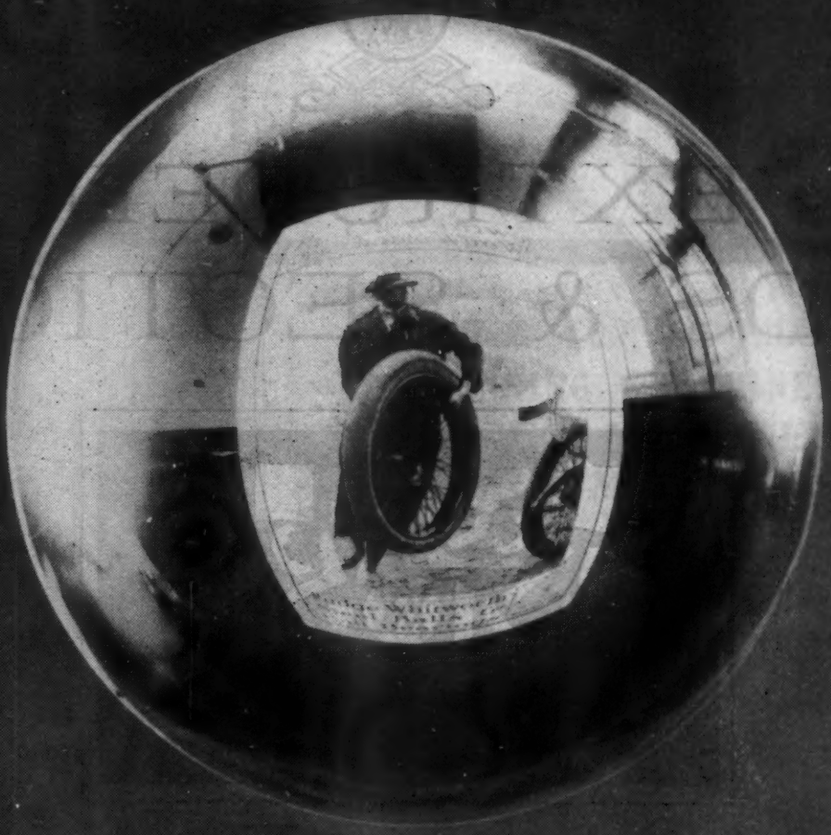
PARKHEAD STEEL WORKS GLASGOW.

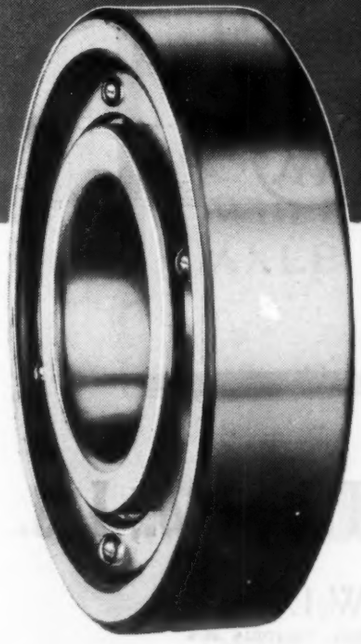
TELEGRAMS:— "BEARDMORE." GLASGOW.

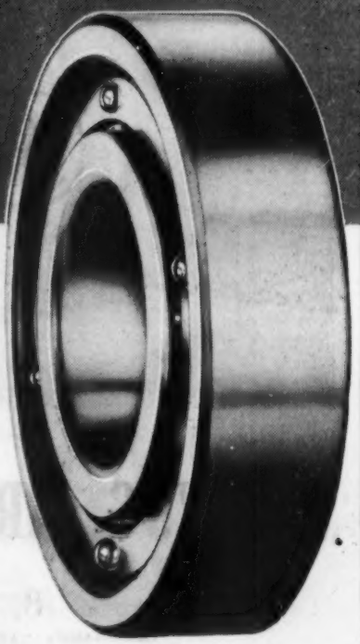
LONDON OFFICE: 36 VICTORIA STR., S.W.

TELEGRAMS:— "BEARDMORE, VIC., "LONDON.

British in Origin and Name







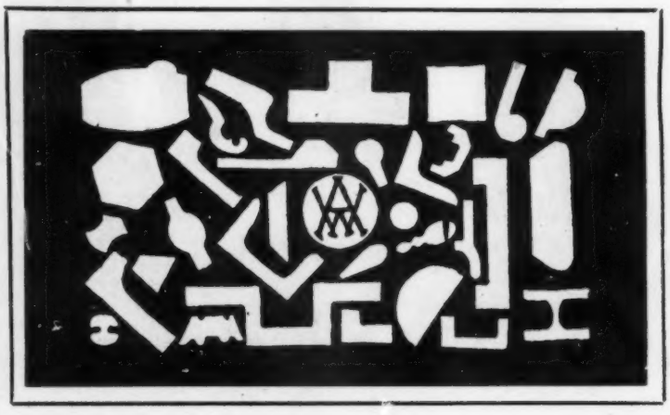
Rudge-Whitworth Steel Balls & Ball Bearings

By Appointment.

Rudge-Whitworth, Ltd Sparkhill, Birmingham.

TRADE MARK

EXTRUDED RODS & SECTIONS



IN

BRASS
COPPER
NAVAL BRASS
YELLOW METAL
ALUMINIUM BRONZE
MANGANESE BRONZE

7602

Sir W. G. ARMSTRONG, WHITWORTH & Co., Ltd.

CENTRAL COMMERCIAL DEPT.:

8, Great George Street, Westminster, S.W.1.

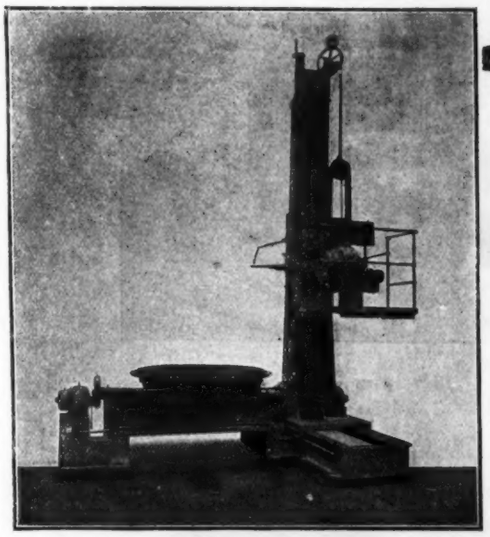
TELEGRAMS: "ARWHITCOY, PARL, LONDON." TELEPHONE: VICTORIA 4010.

DISTRICT OFFICES:

BIRMINGHAM: 158-161, Great Charles Street.
MANCHESTER: 5, John Dalton Street.
GLASGOW: 137A, St. Vincent Street.
LEEDS: Pearl Chambers, East Parade.
NEWCASTLE-UPON-TYNE: Pilgrim House, Pilgrim Street.

TRADE MARK

MACHINE TOOLS

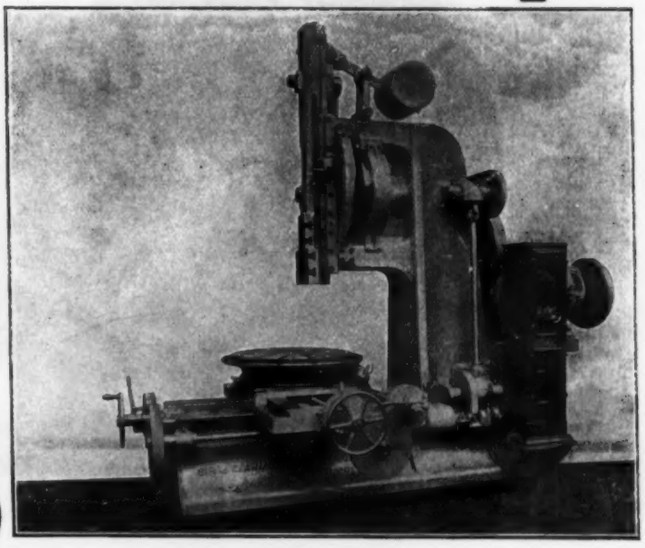


Boiler Shell Drilling Machine.

BORING & TURNING MILLS
TREPANNING MACHINES
DRILLING MACHINES
MILLING MACHINES

Complete Installations of Machine Tools for Railway Workshops and General Engineering Works.

PLANERS
SHAPERS
SLOTTERS
WHEEL LATHES
AXLE LATHES



Heavy Slotting Machine.

Sir W. G. ARMSTRONG, WHITWORTH & Co., Ltd.

CENTRAL COMMERCIAL DEPT.:

8, Great George Street, Westminster, S.W.1.

TELEGRAMS: "ARWHITCOY, PARL, LONDON." TELEPHONE: VICTORIA 4[illegible].

7603

DISTRICT OFFICES:

BIRMINGHAM: 158-161, Great Charles Street.
MANCHESTER: 5, John Dalton Street.
GLASGOW: 137A, St. Vincent Street.
LEEDS: Pearl Chambers, East Parade.
NEWCASTLE-UPON-TYNE: Pilgrim House, Pilgrim Street.

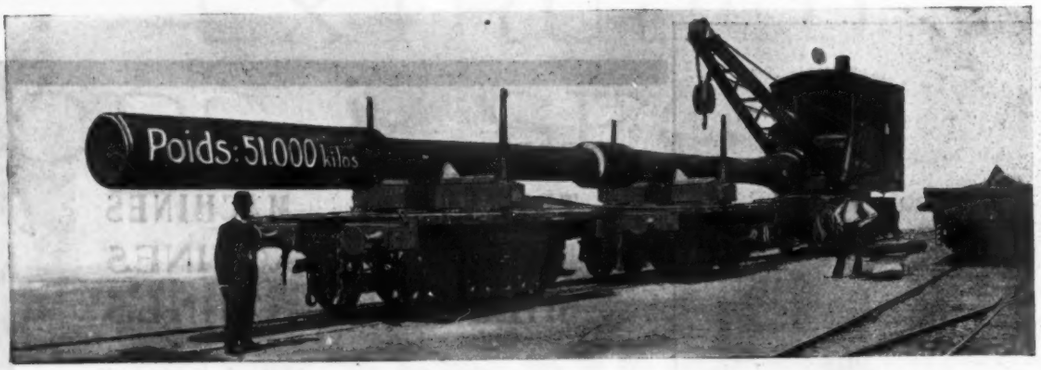
SCHNEIDER & Cie

HEAD OFFICE - - - 42, RUE D'ANJOU, PARIS (8E)

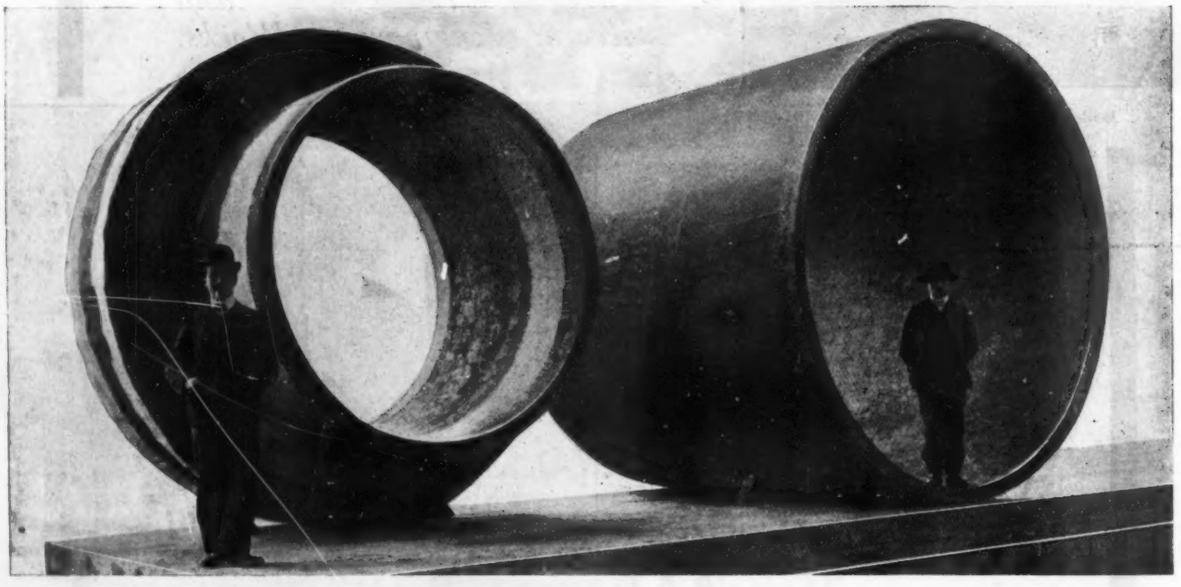
LONDON OFFICE: 2 and 3, NORFOLK STREET, STRAND, W.C. 2

Tel.: Central 2033.

STEEL FORGINGS.



Shaft for a Battleship.



Turbine Drums for the French Battleship "Vergniaud."

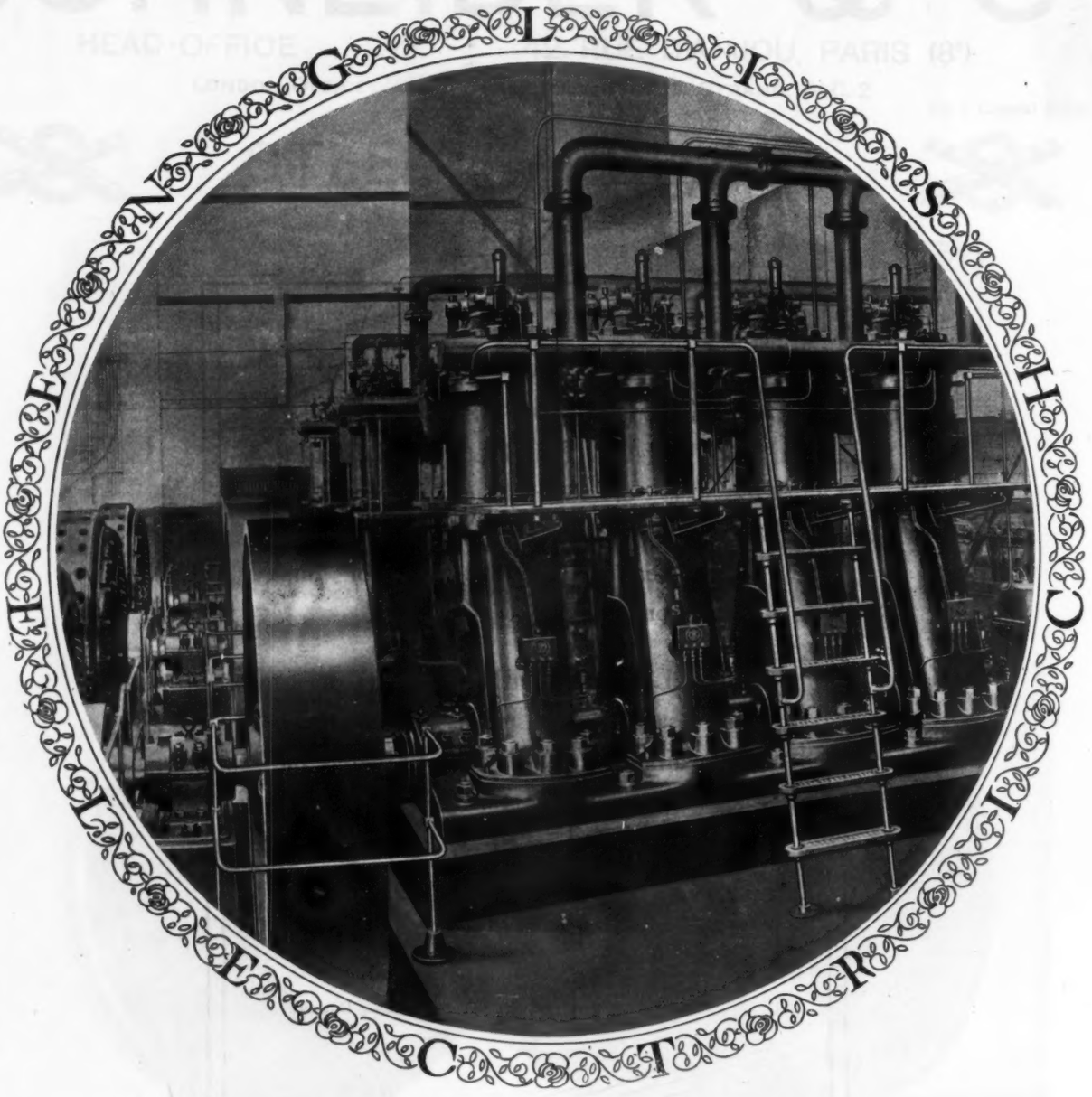
Crankshaft for Aeroplane Engine.

THIS space will be reserved by **CHARLES PURDEN, Ltd.,** for List of their Electric Motors in Stock as on January 1st, 1920, which will appear in the first issue of this paper monthly.

CHARLES PURDEN, Ltd., are doing this to save their customers the unnecessary waiting for replies to their letters of enquiry respecting Motors in Stock.

CHARLES PURDEN, Ltd.,
Lancaster Street,
BIRMINGHAM.
(WALTER PURDEN, Managing Director).

DIESEL ELECTRIC PLANT.



MANUFACTURE of Electrical Plant and Apparatus is specialised at the several works of the Company:—Dick, Kerr Works, Preston; Ordnance Works, Coventry and Scotstoun; Phœnix Works, Bradford; Siemens' Works, Stafford; and Willans' Works, Rugby.

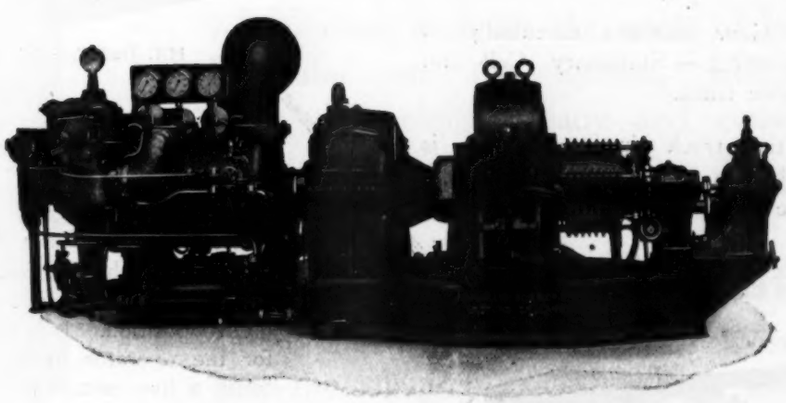
The
ENGLISH-ELECTRIC-COMPANY
LIMITED
QUEENS-HOUSE
Kingsway-London-W.C. 2

Telegrams: "ENELECTICO, WESTCENT, LONDON." Telephone: HOLBORN 830. Cables: "ENELECTICO, LONDON." 7711

W. H. ALLEN, SON & CO., LTD.

TURBINE - DRIVEN MACHINERY.

GEARED or DIRECT DRIVE.



200 K.W. Gear-Driven Turbo Generator.

7814

TURBINE-DRIVEN GENERATORS.
TURBINE-DRIVEN CIRCULATING PUMPS.
TURBINE-DRIVEN FANS.
TURBINE-DRIVEN BILGE PUMPS.
TURBINE-DRIVEN CENTRIFUGAL PUMPS FOR ALL PURPOSES.

BEDFORD, ENGLAND.

K

Absolutely Fool-Proof

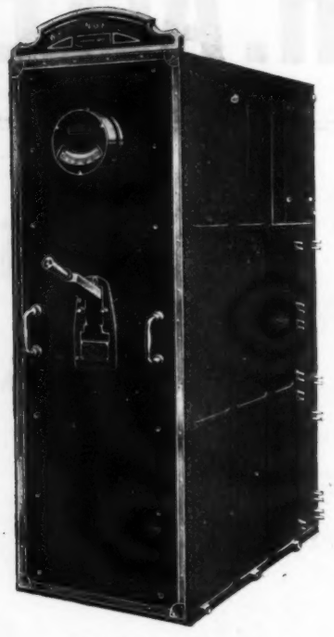
Truck Type - Switchgear

For Low Tension & High Tension A.C. Circuits.

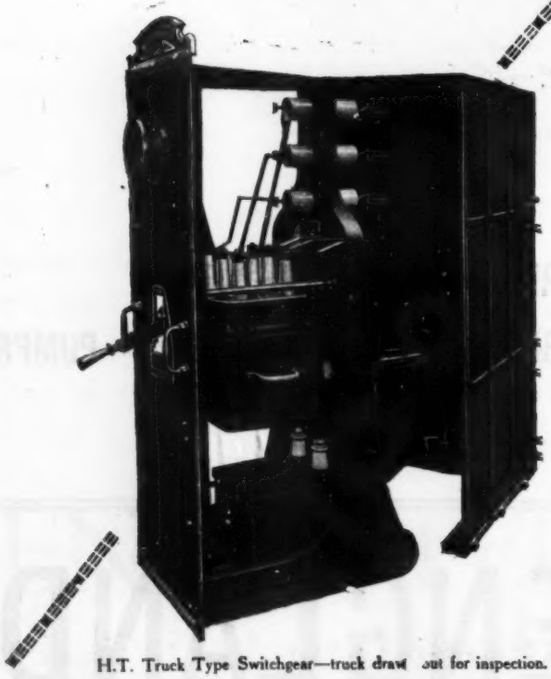
This type of switchgear is of the "Safety First" order and is particularly suitable for installation where space is limited; No passage way at the back is required.

Truck Gear consists essentially of two elements — Stationary Cell and a movable truck.

With the truck in position it is impossible to come into contact with any live parts.



H.T. Truck Type Switchgear.



H.T. Truck Type Switchgear—truck drawn out for inspection.

Switch Truck cannot be withdrawn from the Stationary Cell unless Oil Switch handle is in the "Off" position. It is impossible for the operator to accidentally touch a live metal in Stationary Cell when the truck is withdrawn.

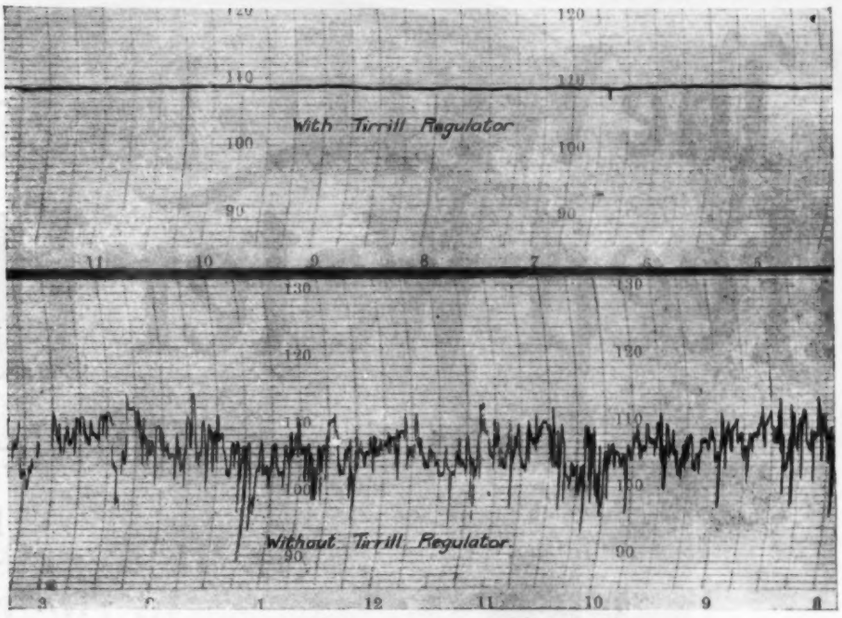
Any number of units can be bolted together to form a complete Switchboard.

It is impossible to receive a shock from this type of switchgear. It is Automatic in its supreme Safety.

Write for Leaflet 85/1-1.

METROPOLITAN Vickers ELECTRICAL CO. LTD.

Trafford Park, Manchester.



Voltage curves of a colliery load with coal cutters running, showing violent fluctuations in voltage from 89 volts to 115 volts without Tirrill Regulator, and a practically straight line at 109 volts with a Tirrill Regulator on the Circuit.

Tirrill Regulator Panels, at National Physical Laboratory, Teddington.

B T-H

The Electrical Hall Mark for Quality

A Straight Line

is the shortest distance between two points, but on a voltage chart it shows the result of installing a Tirrill Regulator on the system, which automatically keeps the voltage steady and constant, and gives

Perfect Voltage Regulation.

Tirrill Regulators

are instruments of unerring precision that automatically keep the voltage constant on either alternating or direct current circuits.

They are automatic in their action, and act instantaneously, so that even with Turbo Alternators with inherently bad regulation a satisfactory voltage is obtained. Time lag is practically non-existent, the moving part of the mechanism is very light with a maximum travel of only about 1/32" and hunting troubles are entirely eliminated.

Write for illustrated List E.G. 2612 on Tirrill Regulators. 7223

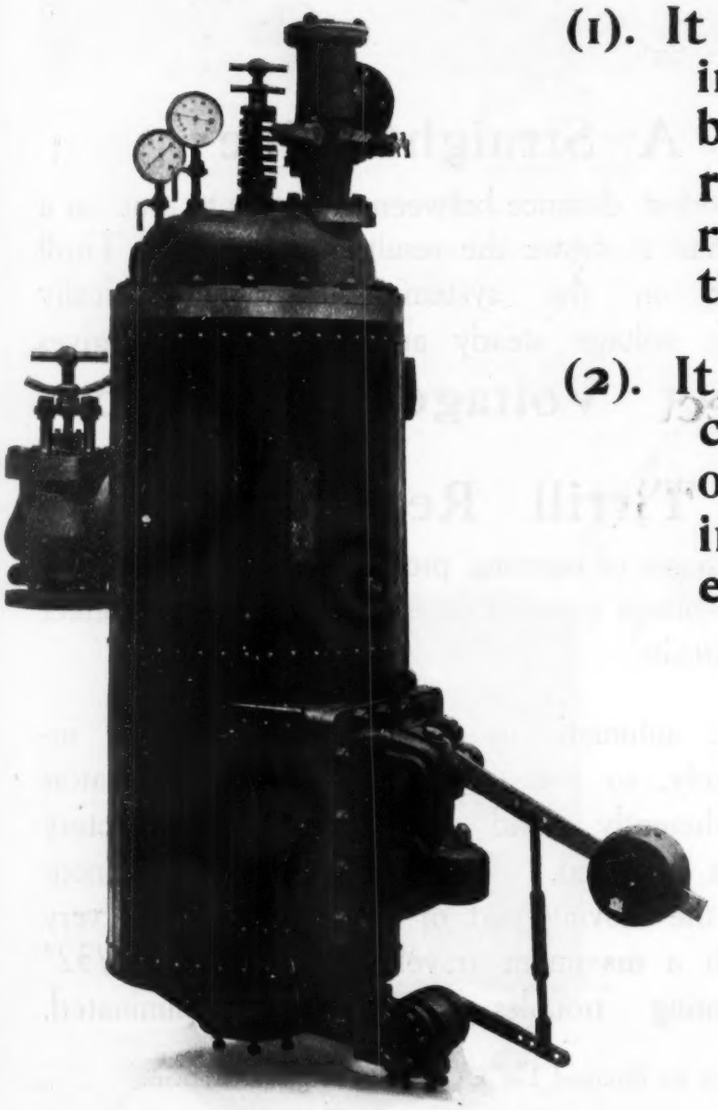
The British Thomson-Houston Co., Ltd.,

Electrical Engineers and Manufacturers,

Head Office and Works - - - Rugby, England.

The WEIR - Direct-Contact - Feed Water Heater

obtains a double economy:



(1). It averts corrosion in the boilers and boiler tubes by removing the corrosive gases from the feed water

(2). It effectively recovers every unit of heat contained in the auxiliary exhaust steam

• • •

The saving in fuel and repair bills is direct and considerable

• •

7270

A simple and efficient machine: imitated but never equalled

G. & J. WEIR, Ltd. CATHCART GLASGOW

VICKERS LIMITED

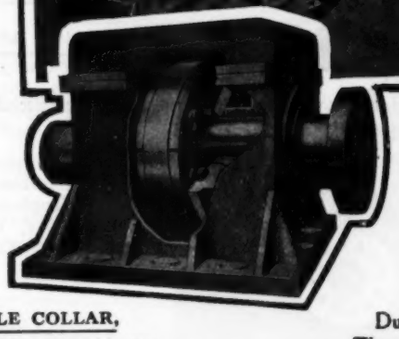
MANUFACTURERS OF

Michell Thrust Bearings

FOR ANY APPLICATION OR LOADING.

SINGLE COLLAR, FORCED LUBRICATION, MARINE THRUST BEARINGS.

MICHELL THRUST BLOCKS UNDER CONSTRUCTION.
—Messrs. Vickers Limited, Barrow.



SINGLE COLLAR,
BATH LUBRICATION,
MARINE THRUST BEARING.

Epoch-Making Invention in Marine Engineering.

During the recent High Court appeal for extension of term of patent for the Michell Thrust Bearing, Mr. Justice Sargant, in giving judgment, said:— The result of this invention has been to increase to an extraordinary extent the efficiency of Thrust Bearings by allowing them to withstand an enormously higher pressure per square inch of surface; their size and cost has been very greatly reduced; their efficiency and reliability has been largely increased, and by reason of the extremely low coefficient of friction, a saving of 2½% to 3% in the power usually wasted in an ordinary Multi-Collar Thrust Block with a consequent saving of a similar percentage of fuel. . . There has also been a great saving in the space occupied, quantity of oil used, and cost of upkeep. . . Repairs and adjustment are practically negligible on the most continuous service. . . Counsel did not put the case too high in claiming this as an epoch-making invention. With either Oil Bath or Forced Lubrication these bearings are entirely reliable and highly efficient. Under the most exacting conditions imposed by Marine Turbines, Reciprocating Engines or Allied Machinery; and are in service taking the thrust on a single collar of a shaft transmitting 25,000 shaft horse power. For land installations of Steam Turbines, Heavy Oil Engines. Air Compressors, Fans, Blowers, Electric Motors, Centrifugal Pumps, Worm Drives, Footstep Bearings, or any other machinery of any type or size, where an axial thrust, with either high or low revolutions, has to be considered. Michell Thrust Bearings are recommended as being particularly suitable.

7721

Head Office:
VICKERS HOUSE,
BROADWAY, LONDON, S.W. 1.

Works:
BARROW-IN-FURNESS, SHEFFIELD, ERITH, BIRMINGHAM, DARTFORD, CRAYFORD, IPSWICH, WEYBRIDGE.

VICKERS

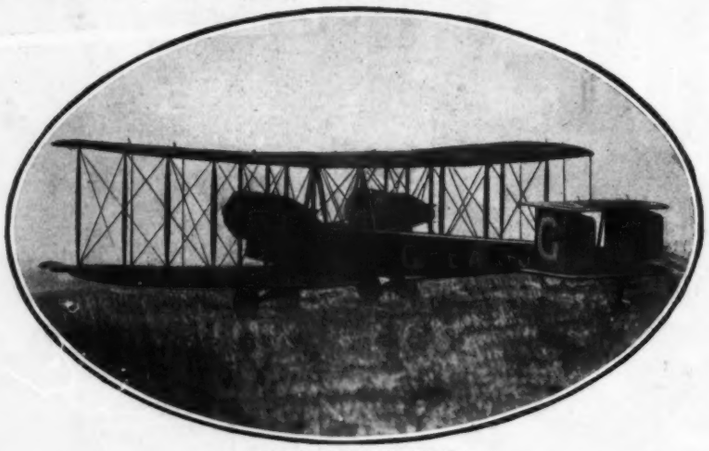
WARSHIPS. MAIL AND PASSENGER STEAMERS.

Icebreakers, Dredgers, and other Special Craft. Floating Docks and Cranes.

Guns and their Mountings. **AIRCRAFT.** Armour Plates.

Marine Engines of all descriptions, including Turbine and Heavy Oil Engines.

Large Gas Engines.



High Efficiency Vacuum Plants, Contraflo Condensers, Kinetic Reciprocating Air Pumps, Cascade Filters, Winch Condensers, Feed Heaters and Evaporators for Land and Marine Installations.

THE START FROM HOUNSLOW.

THE FIRST FLIGHT FROM ENGLAND TO AUSTRALIA.

November 12th to December 10th, 1919.

LIGHT AS ALUMINIUM.
Specific Gravity 2·8

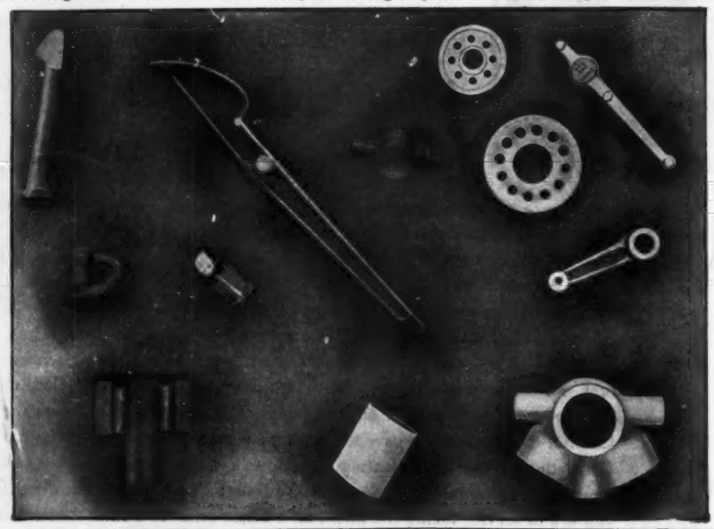
"DURALUMIN"
(REG. TRADE MARK.)

STRONG AS STEEL.
Tensile Strength up to 35 tons.

An alloy of Aluminium with the strength and hardness of Mild Steel, but having only one-third of its weight. Will not rust. Almost unaffected by sea water.

It is an ideal substitute for Aluminium, Nickel, Silver, Brass, Copper, Nickel-Plated and Silvered articles, and it is the only substitute for Steel where Lightness combined with the strength of that metal is required.

For Scientific Apparatus, Instruments of Precision, Orthopædic Apparatus and Hospital Supplies, &c.



For Aeroplanes, Dirigibles, Hydroplanes, Motor Car, Yacht and Boat Fittings, &c.

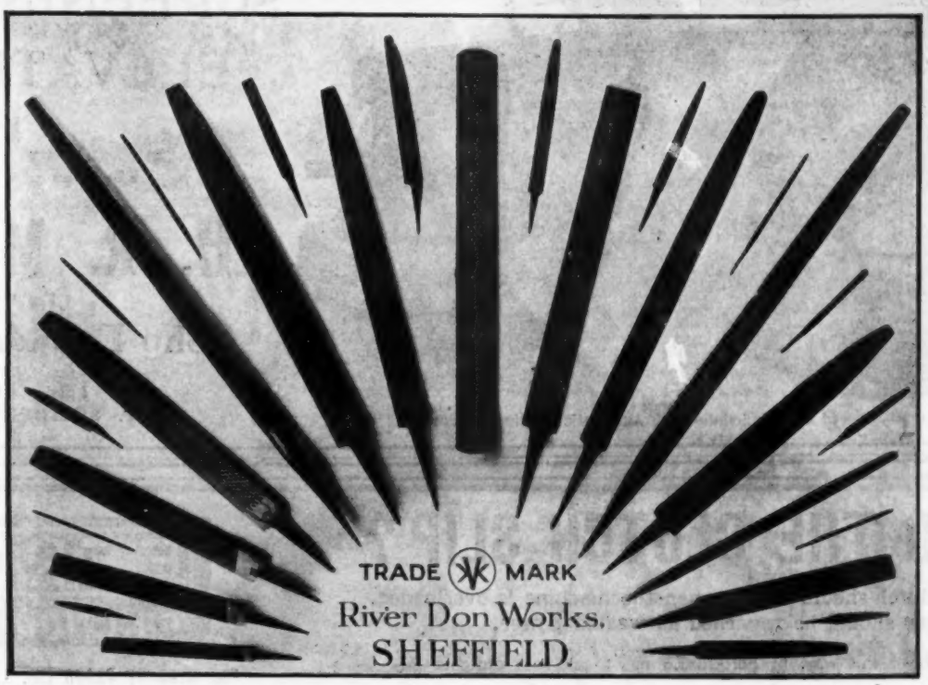
VICKERS HOUSE, BROADWAY, LONDON, S.W. 1.

Licensee and Distributor for the United States:
The AMERICAN DURALUMIN CO.,
Hanover Bank Building, Nassau and Pine Streets, New York.

VICKERS LIMITED,
VICKERS HOUSE, BROADWAY, LONDON, S.W. 1.
Works: BARROW-IN-FURNESS and SHEFFIELD.

VICKERS

FILES



FILES

SPECIAL STEEL FORGINGS

OF ALL DESCRIPTIONS.

"VICKERS-VIMY-ROLLS." AUSTRALIAN AND TRANSATLANTIC FLIGHTS.

The important Forgings of the Engines used on these flights, were made by Vickers Limited, Sheffield, and included Crankshafts, Propeller Shafts and Propeller Hubs.

River Don Works, Sheffield.

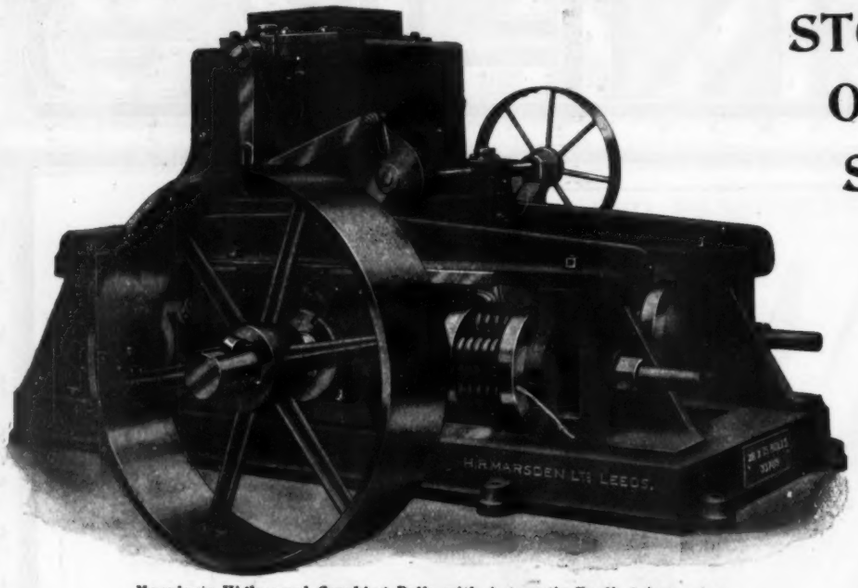
VICKERS LIMITED,

VICKERS HOUSE, BROADWAY, LONDON, S.W. 1.

Works: BARROW-IN-FURNESS, SHEFFIELD, BIRMINGHAM, CRAYFORD, DARTFORD, ERITH, IPSWICH, WEYBRIDGE.

CAST NAME PLATES
AND **INSTRUCTION PLATES.**
FINEST QUALITY.
7166
BUTLER JONES (NAMEPLATES), LTD., DARTMOUTH WORKS, FOREST HILL, LONDON, S.E. 23 'Phone: 946 SYDENHAM

Joseph Booth & Bros.
Limited,
RODLEY, LEEDS.
ALL TYPES & ALL SIZES.
See our Advt. in alternate issues.
CRANES

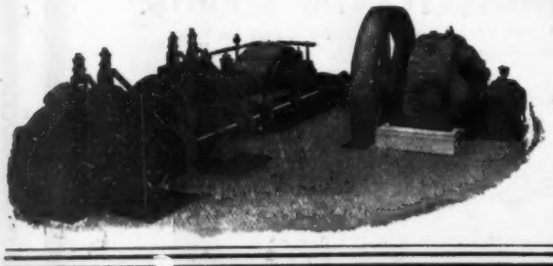
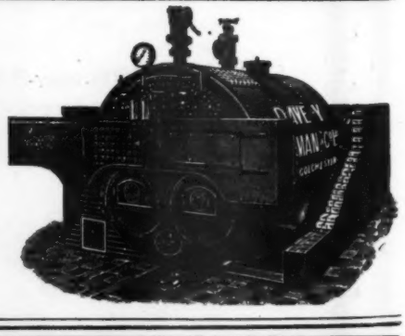


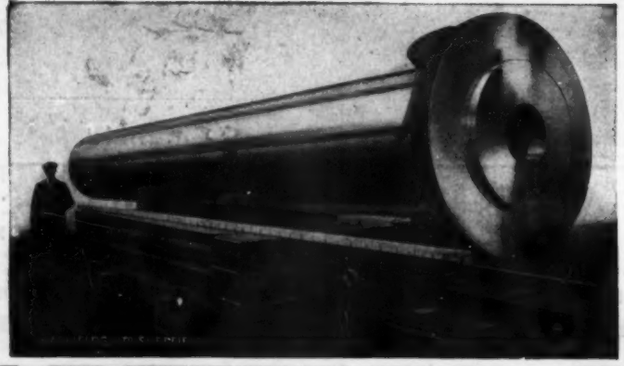
Marsden's High speed Crushing Rolls with Automatic Feeding Apparatus.

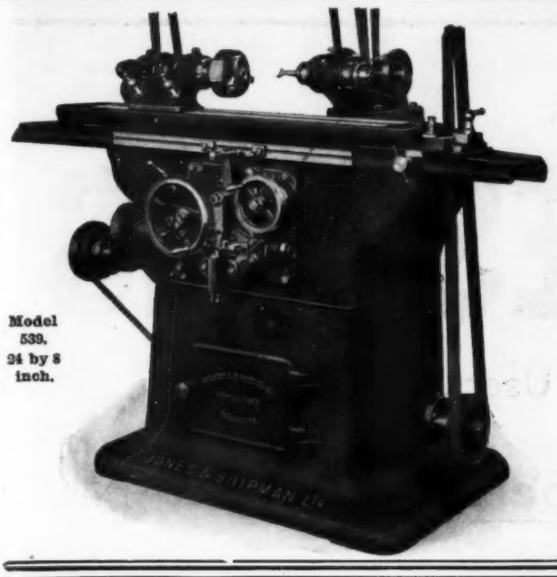
STONE BREAKERS, ORE CRUSHERS, SCREENING AND ELEVATING PLANTS.

H. R. MARSDEN
LIMITED,
Soho Foundry, LEEDS.
8333
London Offices:—
17, ST. SWITHIN'S LANE, E.C. 4.

SHOULD THE CLUTCH SLIP?
The only time a clutch should slip is when the machine is overloaded. Any other slipping should be regarded as wasted power.
If you are losing power this way, fit Ferodo Linings to all your clutches.
A Ferodo-lined Clutch will transmit the maximum power without slipping or seizing, and it will outlast many times any other form of clutch liner.
T 11
8002
FERODO
FRICTION LININGS
The HERBERT FRODO CO., Ltd., Chapel-en-le-Frith.
Contractors to the War Office and Admiralty, London General Omnibus Company, and Underground Electric Railways of London and Paris.
Depots at London, Birmingham, Bristol, Cardiff, Coventry, Edinburgh, Glasgow, Liverpool, Manchester and Newcastle.


Paxman
An economical combination for driving motive power in factories and workshops is the Paxman-Lents and Economic Boiler. :: O 8901
Further particulars upon application to:—
Davey, Paxman & Co., Ltd.,
COLCHESTER, and 78, Queen Victoria Street, E.C.


Manufacturers of
"HECLA" STEEL FORGINGS
(Trade Mark)
For Marine and other Engineering purposes, in the rough, rough machined, or finished.
MADE TO ADMIRALTY, WAR OFFICE, LLOYD'S, BOARD OF TRADE, AND BUREAU VERITAS SPECIFICATIONS.
STEEL CASTINGS
of every description
up to 30 tons in weight.
SPECIAL ALLOY HIGH TENSILE STEEL
FOR AIRCRAFT AND MOTOR CARS.
High Speed Tool Steels
of the first quality.
Workmen employed during the War 15,000.
Works area over 200 acres.

HADFIELDS LTD.
East Hecla and Hecla Works, SHEFFIELD.
Complete Stone Breaking and Ore Crushing Plants.
Sole Makers of
HADFIELD'S PATENT
ERA (TRADE MARK)
MANGANESE STEEL.
THE SUPREME MATERIAL for Railway and Tramway Special Track-work; also Wearing Parts of Stone Breaking, Ore Crushing and other Machinery.
8336
London Office: Norfolk House, Laurence Pountney Hill, E.C. 4.



Model 539. 24 by 8 inch.

DRILLING GRINDING TAPPING and many other kinds of Machine Tools

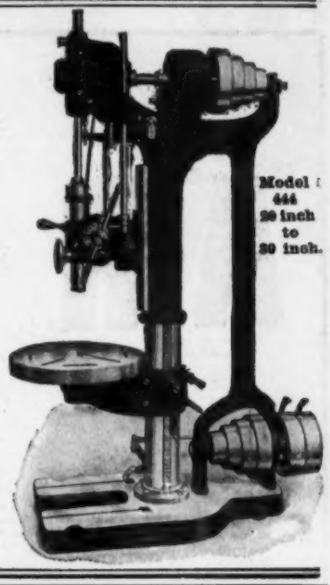
manufactured by

"Jones & Shipman Ltd."

Manufacturers of Modern Machine Tools.

LEICESTER ENGLAND

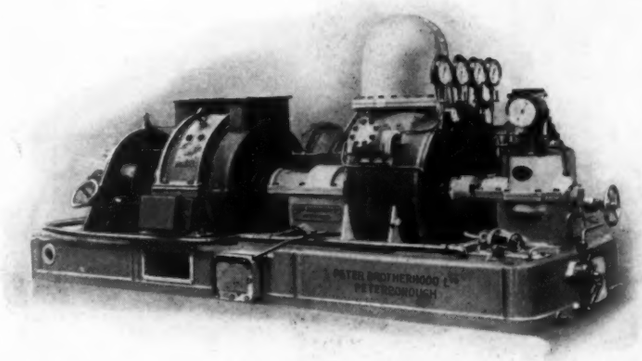
7565



Model 444 20 inch to 30 inch.

IMPULSE TYPE STEAM TURBINES

For Powers up to 1000 HP.



SPECIAL TYPES FOR BACK PRESSURE WORK.

The illustration shows one of the 200 Kw. Turbo-Generators with condensing plant installed in H.M.S. Queen Elizabeth.

PETER BROTHERHOOD, PETERBOROUGH.

7658

GWYNNES

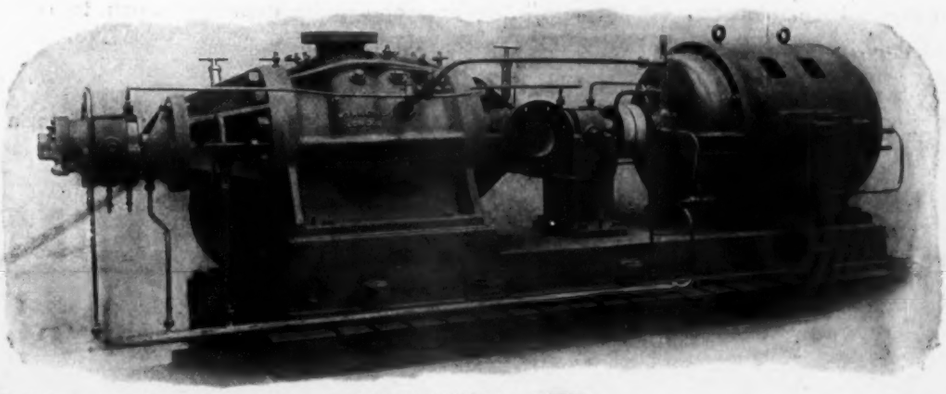
LIMITED.

"INVINCIBLE" CENTRIFUGAL PRESSURE PUMPS FOR HYDRAULIC POWER.

1500 lbs. per square inch or over.

No Accumulators.

Perfect Balance.



Automatic Motor or Steam Turbine Drive.

O 505

GWYNNES LTD.,

HAMMERSMITH, LONDON, W. 6.

"Gwynne, London."

1910 Hammersmith.

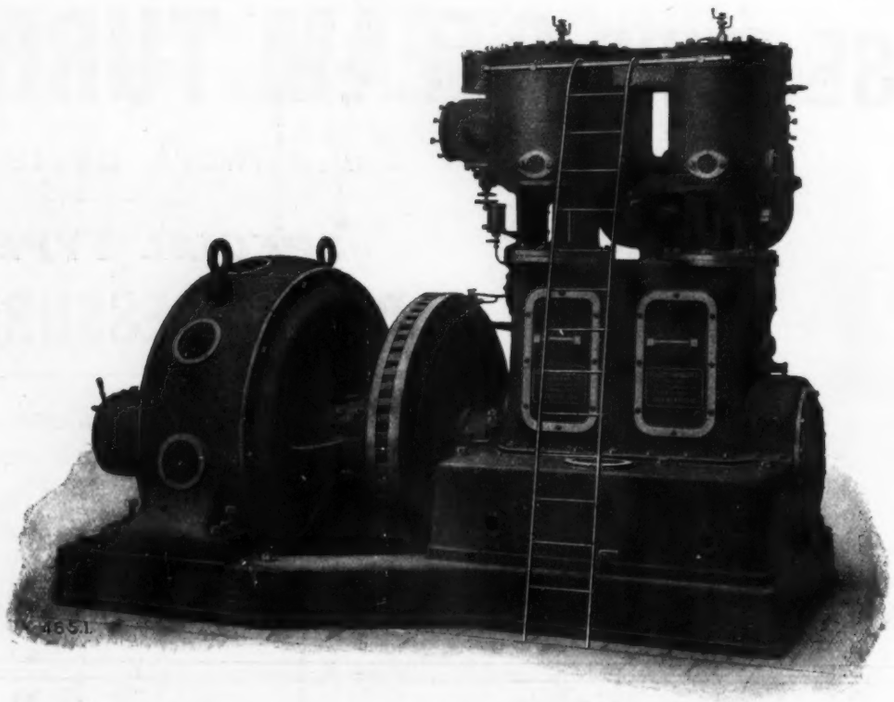
When Requiring

AIR COMPRESSORS

Send for our List of Users

AND

Ascertain their Experience.



TWO-STAGE MOTOR-DRIVEN AIR COMPRESSOR. 1600 cubic feet per min.

Our aim has always been the production of the **"Best"** and **most Efficient** Compressor rather than the cheapest. That this policy is right is proved by the large number of **Repeat Orders.**

Reliability is of **prime importance.** A "Belliss" Compressor can be depended upon to run continuously for long periods of time, with a minimum of attention and cost of up-keep.

Telegrams: BELLISS, BIRMINGHAM. Established 1852. London Office: 8, Victoria St., S.W. I.

BELLISS & MORCOM LIMITED

BIRMINGHAM, ENGLAND.

6563

TILGHMAN'S SAND BLAST APPARATUS

(Arranged for the Operator to work either inside or outside the Sand Blast Chamber)

FOR CLEANING LARGE AND SMALL CASTINGS.

WILL SAVE 50 PER CENT. IN FETTLERS' WAGES.

IN USE BY THE FOLLOWING WELL-KNOWN FIRMS:

STEEL CASTINGS.		ORDINARY IRON CASTINGS.		MALLEABLE IRON.		BRASS OR GUNMETAL.	
Beardmore, W., & Co., Ltd.	Glasgow	Platt Bros. & Co., Ltd.	Oldham	Ley's Malleable Castings Co., Ltd.	Derby	Vickers Limited	Barrow
Steel Co. of Scotland	Glasgow	Tweedales & Smalley	Castleton	Crowley, John, & Co., Ltd.	Sheffield	Gummer & Co.	Rotherham
Coltness Iron Co.	Coltness	H.M. Dockyards	—	Baker Foundry Co., Ltd.	Smethwick	Ruston, Proctor & Co., Ltd.	Lincoln
Dickson & Manns, Ltd.	Armadale	Dobson & Barlow, Ltd.	Bolton	Maddocks J., & Co., Ltd.	Oakengates	Storey, Isaac, & Sons, Ltd.	Manchester
Vickers Limited	Barrow	Doulton & Co., Ltd.	Paisley	Clegg & Howgate, Ltd.	Keighley	Glenfield & Kennedy	Kilmarnock
Darlington Forge Co., Ltd.	Darlington	Ruston, Proctor & Co., Ltd.	Lincoln	Croft Foundry Co., Ltd.	Walsall	Milne, J., & Son	Edinburgh
Shaw, W., & Co.	Middlesbrough	Marshall, Sons, & Co., Ltd.	Gainsborough	Lindop, H. W.	Walsall	Benton & Stone	Birmingham
Hadfields' Steel Foundry Co., Ltd.	Sheffield	Shanks & Co., Ltd.	Barrhead	Tangyes Ltd.	Birmingham	British Insulated & Helsby Cables, Ltd.	—
Osborn, S., & Co., Ltd.	Sheffield	Falkirk Iron Co.	Falkirk	Harper, J., & Co.	Willenhall	Marshall, Sons, & Co., Ltd.	Gainsborough
Jackson, F. R., & Co., Ltd.	Manchester	Hopkinson & Co.	Huddersfield	Haden, G. N., & Sons	Trowbridge	Dewrance & Co.	London
Atlas Steel Foundry & Eng. Co., Ltd.	Armadale	A. Kenrick & Sons, Ltd.	West Bromwich	Brampton Bros.	Birmingham	Barr & Strouds Patents	Glasgow
John Spencer & Sons, Ltd.	Newcastle-on-Tyne	Cannon Iron Foundries	Wolverhampton	Clive, Thos., & Son	Birmingham	Hopkinson & Co., Ltd.	Huddersfield
Cammell Laird & Co., Ltd.	Sheffield	Holcroft, Thos., & Sons, Ltd.	Wolverhampton	Gameson, T., & Sons, Ltd.	Walsall	Harlow & Son	Stockport
Brown, John, & Co., Ltd.	Sheffield	Geo. Salter & Co.	West Bromwich	Hackett & Sons	West Bromwich	Woodhouse & Co.	Doncaster
Allen, E., & Co., Ltd.	Sheffield	Clark, T. and C., & Co.	Wolverhampton	Hill, H. and J.	Willenhall	Hill, C. and L.	Willenhall
Electro Flex. Steel Co., Ltd.	Newcastle-on-Tyne	Swain, Matthew, Ltd.	Manchester	Parkes, G. B., Ltd.	Halesowen	Showell, E., & Sons, Ltd.	Birmingham

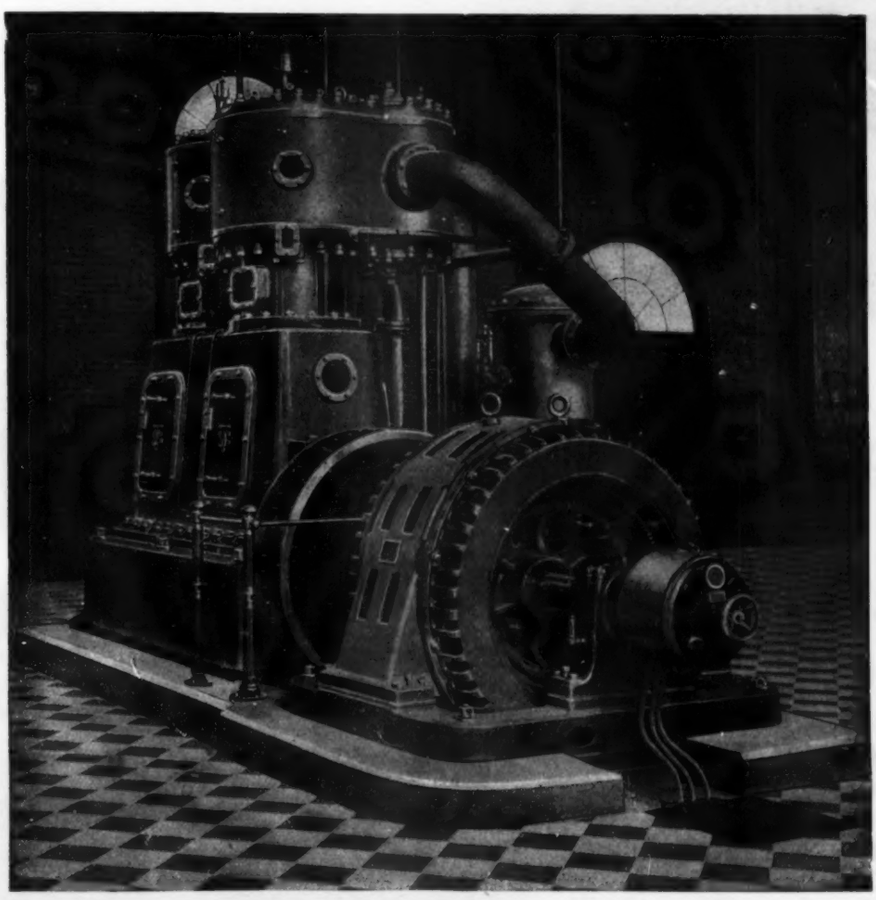
Representative; GEO. HOPKINS, 10, Sanctuary House, Broadway, Westminster, S.W.

TILGHMAN'S PATENT SAND BLAST CO., Limited,

BROADHEATH, NEAR MANCHESTER.

TILGHMAN'S AIR COMPRESSORS.

FOR ALL PURPOSES. OVER 4,000 SUPPLIED.



STANDARD TYPE AIR COMPRESSOR WORKING AT A COLLIERY. Capacity 2,500 cubic feet per minute. Pressure 100 lbs., 295 R.P.M.

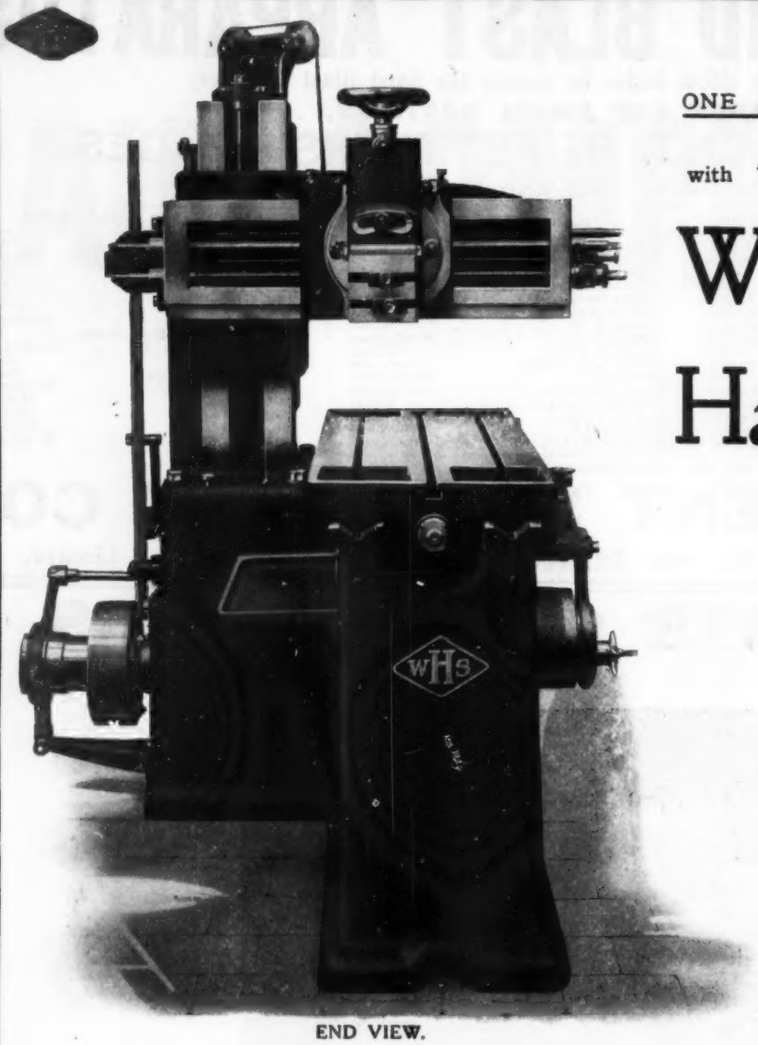
Standard Vertical and Horizontal Enclosed Types 50 to 5,000 cubic feet per minute. The outstanding features of these machines are SIMPLICITY, RELIABILITY, ACCESSIBILITY and EFFICIENCY combined with silent working at high speed.

Amongst the users of these Compressors are the following well-known firms:—

SIR RAYLTON DIXON & Co., Ltd., Middlesbrough.
SIR W. G. ARMSTRONG, WHITWORTH & Co., Ltd., Newcastle-on-Tyne.
GREAT WESTERN COLLIERY Co., Ltd., Pontypridd.
CLIFTON & KEARSLEY COAL Co., Ltd., Manchester.
VULCAN FOUNDRY Ltd., Newton-le-Willows.
MIDLAND COAL, COKE & IRON Co., Ltd., Newcastle.
SKINNINGROVE IRON Co., Ltd., Saltburn-by-the-Sea.
CHAS. RENNOLDSON & Co., South Shields.
OSBOURNE, GRAHAM & Co., Ltd., Sunderland.
TYNE IRON SHIPBUILDING Co., Ltd., Willington-on-Tyne.
BABCOCK & WILCOX, Renfrew.
BLYTH SHIPBUILDING & DRY DOCKS Co. Ltd. Blyth.
H.M. DOCKYARD, Haulbowline.
MANCHESTER DRY DOCKS Co., Ltd., Manchester.
MERCANTILE DRY DOCKS Co., Ltd., Jarrow-on-Tyne.
COOK, WELTON & GEMMELL, Ltd., Beverley.
JOHN READHEAD & SONS, Ltd., South Shields.
ARDROSSAN DRY DOCK & SHIPBUILDING Co., Ltd

741

TILGHMAN'S PATENT SAND BLAST CO., LTD., Broadheath near Manchester.



END VIEW.

For Immediate Delivery :—

ONE BATEMAN TOP SPEED PLANER,

54 in. by 48 in. by 14 ft.

with Three Tool Boxes and Belt Driven.

Ward,

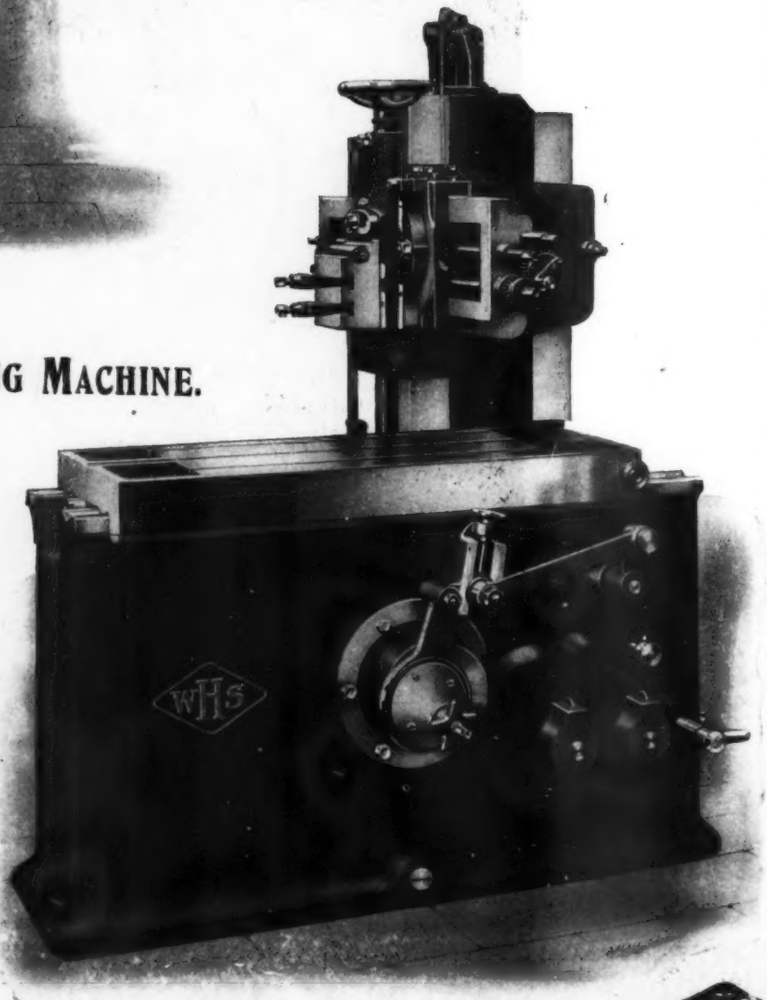
Haggas & Smith,

EASTWOOD,

KEIGHLEY,

ENGLAND.

24" STROKE OPENSIDE PLANING MACHINE.



FRONT VIEW.

Please Ask for Our

NEW PLANER CATALOGUE.

6820

Head Office and Works: KEIGHLEY.

Telephone: 154 KEIGHLEY.

Telegrams and Cables: "PLANERS, KEIGHLEY."

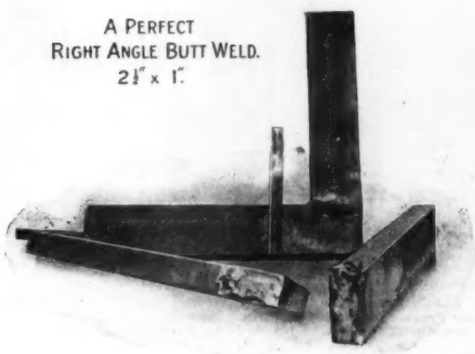
Codes Used: A B C (5th Edition), LIEBERS, and PRIVATE.

LONDON OFFICE:
33, VICTORIA ST., WESTMINSTER, S.W.
Telegrams: "VILVALLE, LONDON."
Telephone: 3190 VICTORIA (Two lines).

GLASGOW OFFICE:
CENTRAL CHAMBERS, HOPE ST.
Telegrams: "FAIRMAN, GLASGOW."
Telephone: 210 CENTRAL

"A-I" System of Electric Welding

A PERFECT
RIGHT ANGLE BUTT WELD.
2½" x 1".



"A-I" in name

A. 1 in quality

Butt Welding

2½ ins. by 1 in. = 2½ sq. in area—welded in 1 minute 40 seconds—one skilled man, no helper, 99½% perfect welds, after dressing 93% of the original strength of the metal, perfect right-angle, perfectly level.

Old method—a forge, a blacksmith, a striker, at least half an hour, a serious percentage of bad welds, no certainty of clean welded centres, guaranteed alignment of right-angle impossible.

Which is the efficiency method?

London Representative:

Mr. J. COULTON (Dept. D), Bevois House, 28, Basinghall Street, E.C. 2.
Telephone: 5979 London Wall. Telegrams: "Cycoultond, Ave," London.

Selling Agents:

RD. JOHNSON, CLAPHAM & MORRIS, LTD. (Dept. D), 24 & 26, Lever St., MANCHESTER.
Telephone: Central 1120 (9 Direct Lines.) Telegrams: "Metallicus," Manchester.

PERKIN & CO., LTD. (Dept. D), Junction Works, Whitehall Road, LEEDS.
Telephone: 26805. Telegrams: "Perco," Leeds.

Made by:

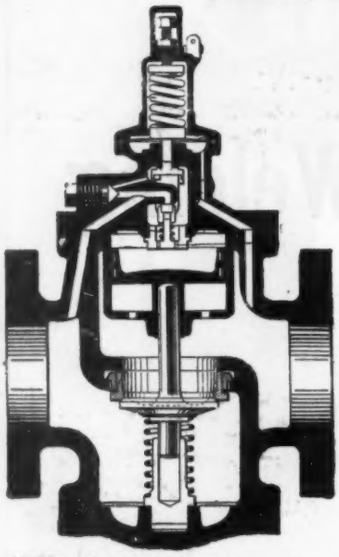
A-I MANUFACTURING COMPANY (Dept. D), Industry Works, Sunbridge Road, BRADFORD.
Telephones: 5152, 5153. Telegrams: "Patterns," Bradford.

(Agencies in other countries.)

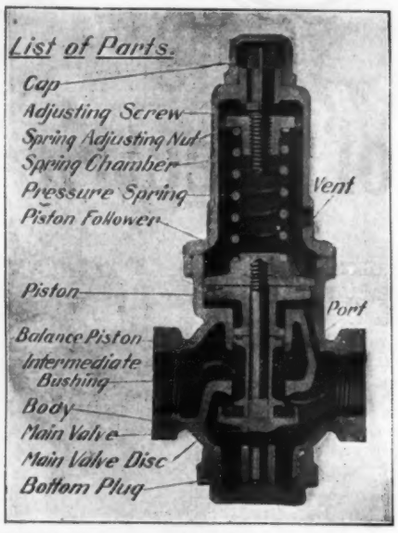
7390

LEADING "VALVES OF PRECISION"

WHICH DO WORK UNATTEMPTED WITH ANY OTHER DESIGN.

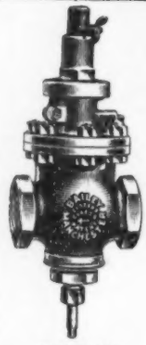


FOSTER CLASS "G" REDUCING VALVE. Most compact. Single Seat. Works any way up. Dead-tight. Self-contained. Closest Regulation.



FOSTER CLASS "U" REDUCING VALVE. For Air and Water Pressures. Steady Control. Dead-tight. "Water Drawn—off or not." No outside Levers, Pipes, &c.

Fig. 1770.—CLASS "W" STANDARD REDUCING VALVE. Adapts itself instantly to all demands.



"FOSTER" FAN ENGINE **REGULATOR.** Speed of Fan controlled by pressure in boiler.

We are the only Makers of

FOSTER'S PATENT PRESSURE

REDUCING VALVES

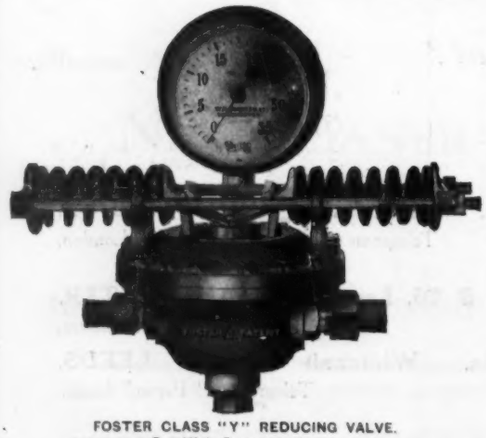
SPECIFY ALWAYS BAILEY'S FOSTER'S PATENT

PRESSURE REDUCING VALVES.

BAILEY'S "FOSTER" VALVES are supplying Steam to **EXHAUST and MIXED PRESSURE TURBINES; REDUCING 300 lb. down to Atmosphere in one stage.**

—

REDUCING AND REGULATING VALVES. for every purpose.



FOSTER CLASS "Y" REDUCING VALVE. For High Pressure Gases.

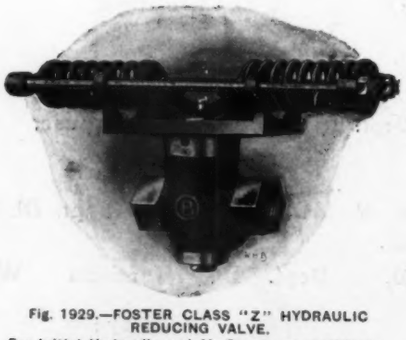


Fig. 1929.—FOSTER CLASS "Z" HYDRAULIC REDUCING VALVE. For Initial Hydraulic and Air Pressures of 3000 lbs.

FOSTER CLASS "Y" REDUCING VALVE. For Reducing Initial Pressures of 3500-2000 lbs. to 250 lbs. Designed for Acetylene Welding, Pneumatic Rivetting, &c. 7741

MANUFACTURED BY

SIR W. H. BAILEY & Co., LD.

AT THE ALBION WORKS, SALFORD, MANCHESTER.

C. A. Parsons & Co., Ltd

HEATON WORKS, NEWCASTLE ON TYNE

LONDON OFFICE: 8 VICTORIA ST., S.W.1.

Manufacturers of

Steam Turbines,

Alternators,

Turbo Air Compressors,

Condensing Plant, Turbo Blowers,

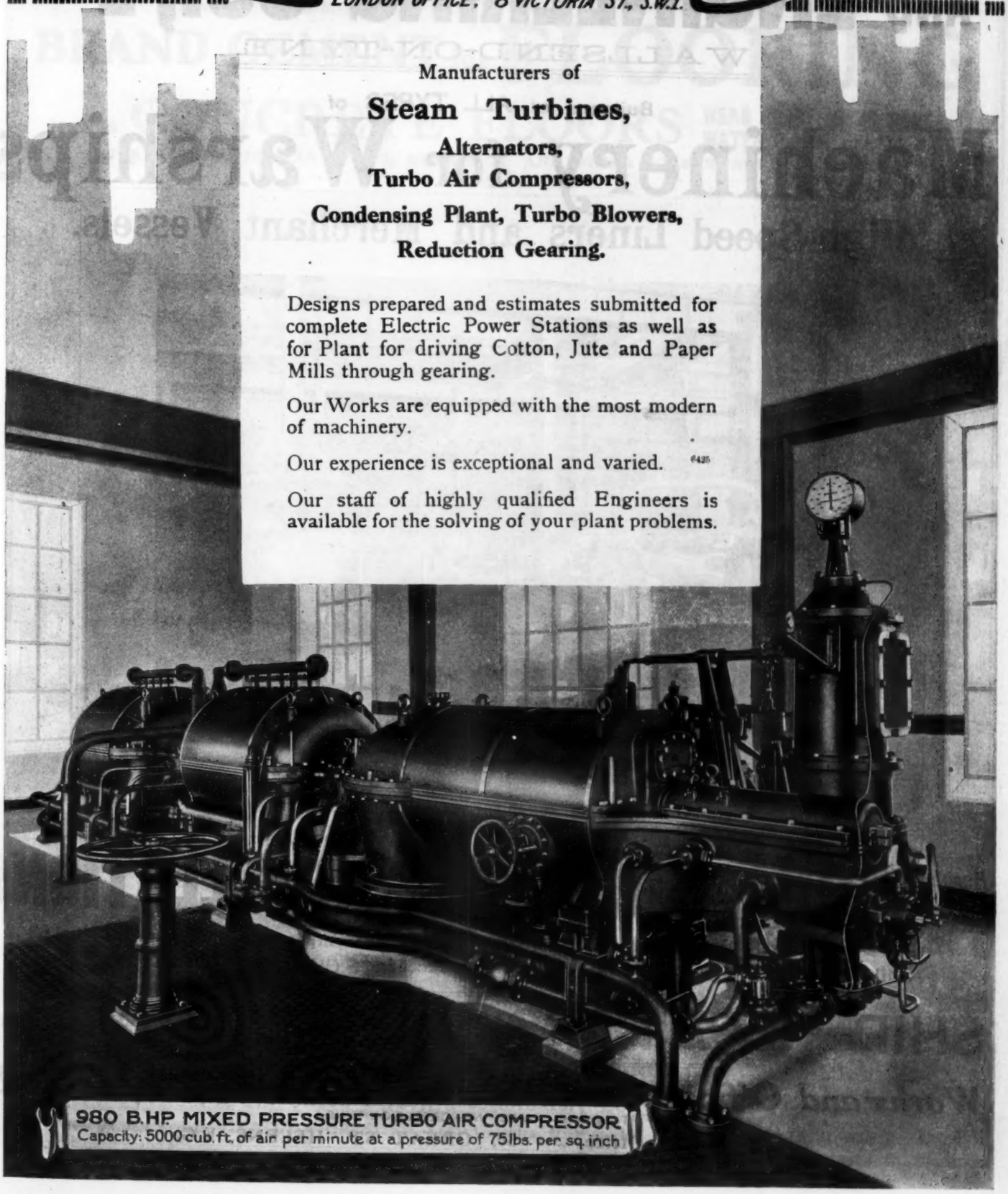
Reduction Gearing.

Designs prepared and estimates submitted for complete Electric Power Stations as well as for Plant for driving Cotton, Jute and Paper Mills through gearing.

Our Works are equipped with the most modern of machinery.

Our experience is exceptional and varied. 6425

Our staff of highly qualified Engineers is available for the solving of your plant problems.



980 B.HP. MIXED PRESSURE TURBO AIR COMPRESSOR.
Capacity: 5000 cub. ft. of air per minute at a pressure of 75 lbs. per sq. inch

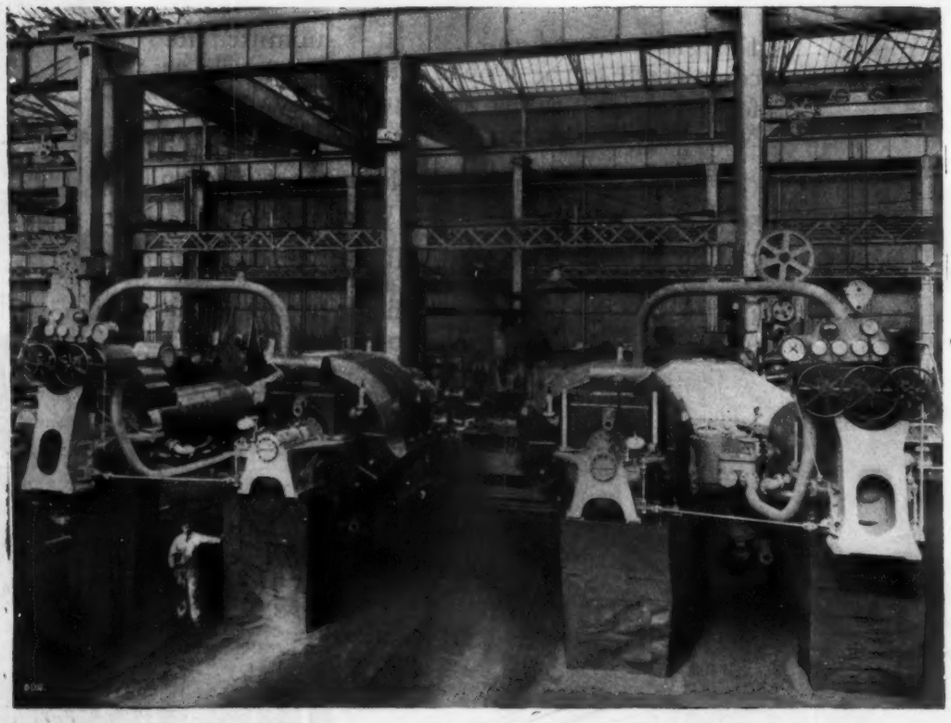
THE WALLSEND SLIPWAY AND ENGINEERING CO., LTD.

WALLSEND-ON-TYNE

Builders of ALL TYPES of

Machinery for Warships

High-Speed Liners and Merchant Vessels.



SET OF TWIN-SCREW GEARED TURBINE ENGINES FOR LARGE MERCHANT VESSEL.

Manufacturers — of

OIL BURNING INSTALLATIONS

More than 300 Vessels have been fitted up by the Company for burning oil fuel; while the aggregate power of Boilers so fitted exceeds 3,000,000 HORSE POWER. 6515

SHIP REPAIRERS.

Graving Dock 540 ft. long.

Works and Offices - - - - WALLSEND-ON-TYNE.

Telegrams—"WALL, NEWCASTLE-ON-TYNE."

LONDON Office - 30, GREAT ST. HELENS, E.C.

"IRONITE"

ENTIRELY BRITISH

Registered Trade Mark.

BRAND CEMENT for FLOORING

MAKES **CONCRETE FLOORS** WEAR PROOF, DUST PROOF, WATER PROOF, GREASE PROOF.

CONTRACTORS TO WAR OFFICE, ADMIRALTY, AND OTHER GOVERNMENT DEPARTMENTS.

LARGE GOVERNMENT RESERVOIR RENDERED TIGHT WITH IRONITE.

Also "IRONITE" BRAND CEMENT for WATERPROOFING.

For rendering, *at a very low cost,* Cement, Bricks, Concrete, Wood, &c., *absolutely Waterproof and Oil Proof* against heavy pressure.

FLAT ROOFS rendered Waterproof at less than half the cost of Asphalt.

For full particulars apply to—

The IRONITE COMPANY, Limited

(Managers—S. THORNELY MOTT & VINES, Ltd.),

7343

TELEPHONE— No. 5618 VICTORIA.

11, Old Queen Street, Westminster, LONDON, S.W. 1.

TELEGRAMS— THORMOTVIN, VIC., LONDON.

Sole Indian Agents—HEATLY & GRESHAM, Ltd., Calcutta, 6, Waterloo Street; Bombay, 75, Hornby Road.

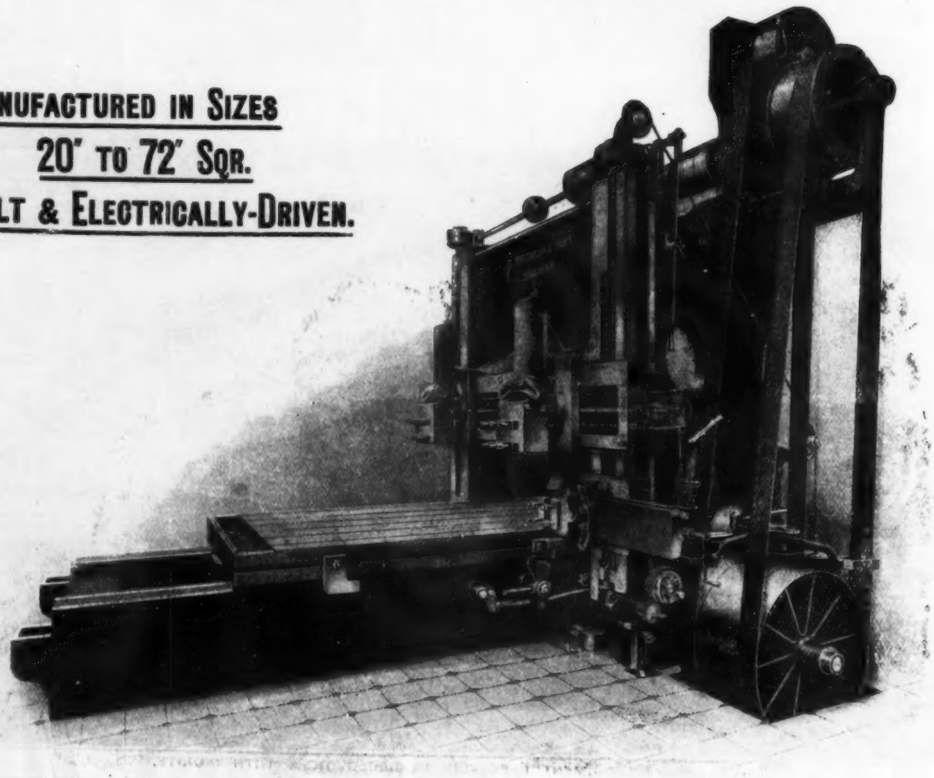
RRP RRP

WHY A "REDMAN"?

BECAUSE IT IS A CAPITAL INVESTMENT FOR REDUCING YOUR LABOUR COSTS

THIS IS THE VITAL POINT THAT STRIKES ALL WHO USE THEM

MANUFACTURED IN SIZES
20" TO 72" SQR.
BELT & ELECTRICALLY-DRIVEN.



8053

ILLUSTRATION OF 5' × 5' × 10' SELF-CONTAINED.
ELECTRICALLY-DRIVEN.

C. REDMAN & SONS, LTD., PLANER SPECIALISTS, KINGSTON, HALIFAX.

Telegrams and Cables:
"PLANERS, HALIFAX."

TEL. 308.

Codes: LIEBERS (5 letter), and ABC (5th Edition), and MARCONI INTERNATIONAL.

RRP RRP

Save Time

—*and* Capital—*and* Labour—*and* Repairs

by installing our intercommunicating phone. You are then *directly in touch* with every department—however extensive your premises are. You can talk *instanter* with any of your Managers or Foremen. Invaluable in Shipyards, Foundries, Offices, etc.

7437

Particulars from

THE TELEPHONE MANUFACTURING Co., Ld.

WEST DULWICH,
LONDON, S.E. 21

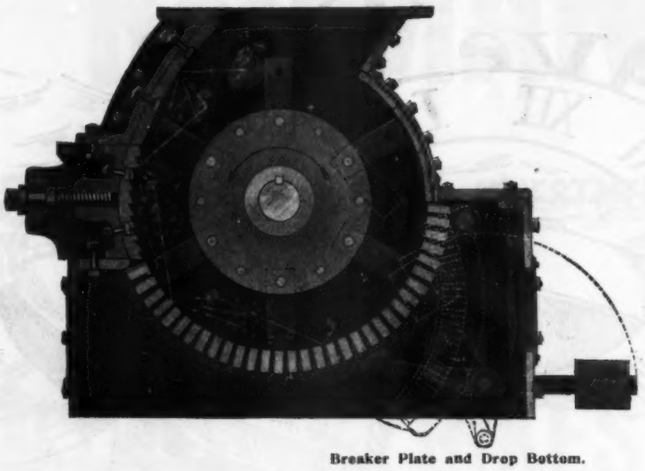
Telephone: *Sydenham 1067*
Telegrams: *Bubastis—Dulcrox*

The Illustration shows a desk instrument for 20 lines, with microphone and automatic communication

JEFFREY TYPE "B" SWING HAMMER PULVERIZER FOR COKE PLANTS.

Reduces Run-of-Mine Coal to ¼ inch to dust for coking purposes.

The product of this pulverizer insures first class coke.



Breaker Plate and Drop Bottom.

None of the product can get by without pulverization, yet the Drop Bottom permits tramp iron to be disposed of without injury to the machine.

Built in several sizes with capacities ranging from 10 to 250 tons per hour.

MANUFACTURERS OF ELEVATING, CONVEYING, SCREENING, CRUSHING, POWER TRANSMISSION MACHINERY; COAL MINING MACHINERY, ETC.

Write for Catalogues on the line you are interested in. 7683

THE JEFFREY MFG. CO., — EXPORT DIVISION, — 910 NORTH FOURTH STREET, **COLUMBUS, OHIO, U.S.A.**

Sole Agents for England.—Messrs. HUGH WOOD & CO., LTD., Newcastle-on-Tyne and 65 Fenchurch Street, London.

"JEFFREY" ELECTRIC LOCOMOTIVES.

A 12½ Ton
STORAGE BATTERY
LOCOMOTIVE
Hauling and Shunting at
Trafford Park, Manchester.

8148

HUGH WOOD & CO., LTD.,

65, FENCHURCH STREET, LONDON, E.C. 3.

Telegrams: "HUWOD, FEN., LONDON." Telephone: AVENUE 1545.

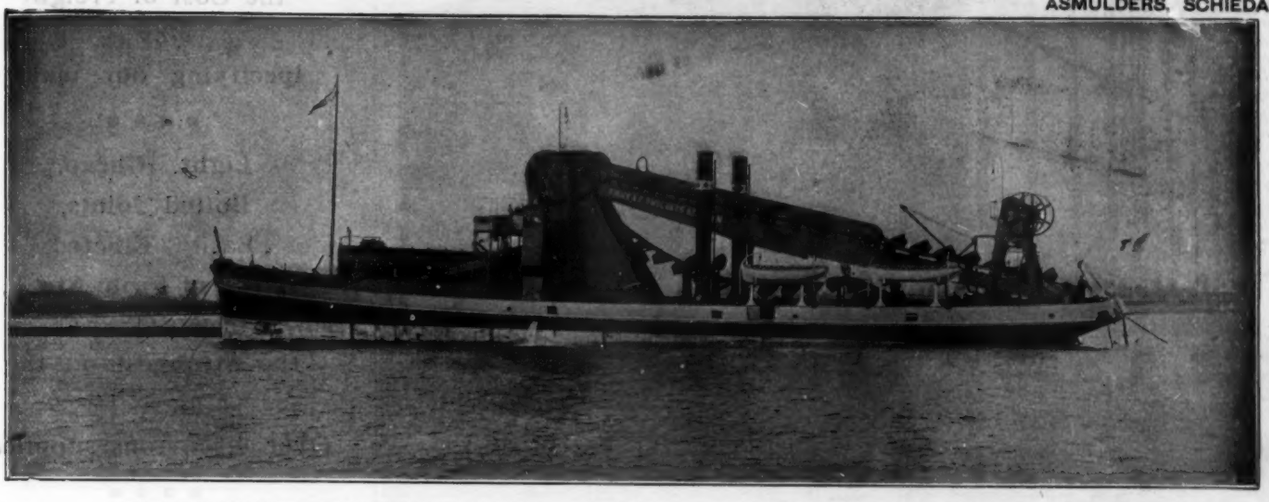
Head Office: NEWCASTLE-ON-TYNE. And at MANCHESTER and CARDIFF.

WERF GUSTO

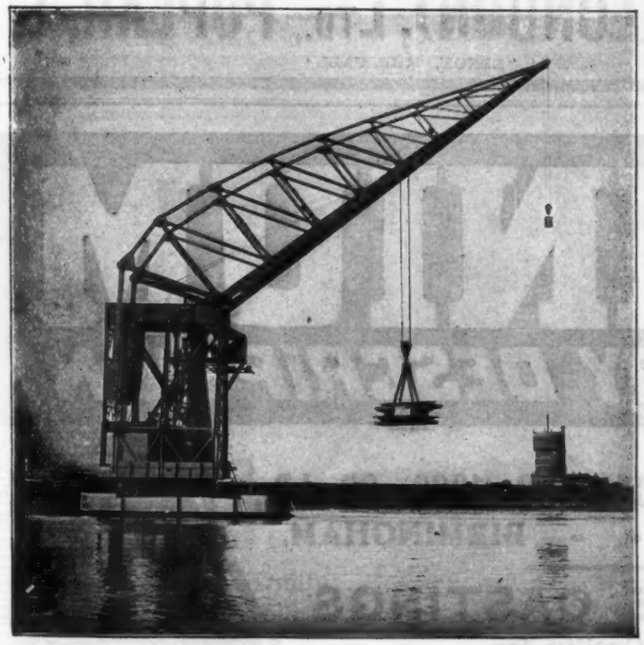
FIRMA A. F. SMULDERS, SCHIEDAM (HOLLAND).

Sole Agent United Kingdom—ANDERSON RODGER, 38, Victoria St., Westminster, London, S.W.

TELEGRAPHIC ADDRESS—
ASMULDERS, SCHIEDAM.



SEA-GOING TWIN-SCREW BUCKET HOPPER DREDGER—WITH SUCTION AND FORCE PUMP—"VENEZIA."



150 TONS DERRICKING AND REVOLVING FLOATING CRANE.

Height above Waterline	...	...	60,75 M—196 ft.
Lifting Radius for 40 Tons		...	45,50 M—149 ft.
Ditto ditto	110 Tons	...	26,50 M— 87 ft.
Ditto ditto	150 Tons	...	26,50 M— 87 ft.

COAL ELEVATOR "WESTFALEN."
Having a Guaranteed Contractural Output of 600 Tons per Hour, which ran up to over 1000 Tons per Hour at the Trials.

DEPARTMENTS:

A. DREDGING PLANT of ALL TYPES up to the LARGEST capacities.

B. COALING VESSELS BUNKERING STEAMERS MECHANICALLY at rates from 150 to 1000 Tons per Hour and upwards.

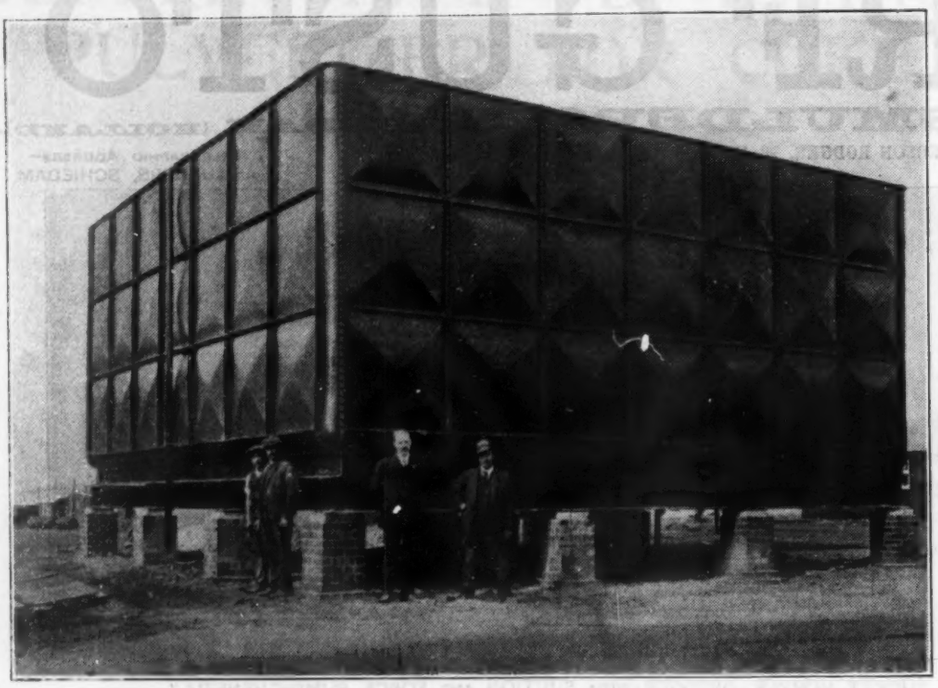
C. FLOATING CRANES of great Power, from 50 to 400 Tons and upwards.
(Of late years we have supplied 23 of these Cranes, ranging in power from 60 to 400 Tons.)

BOILERS of every description; BRIDGE and ROOF CONSTRUCTION, by our own Boiler Works—A. F. SMULDERS, Grace-Berleur, nr. Liege, Belgium.

7933

GUEST-LENOX PATENT PRESSED STEEL SECTIONAL TANKS

As Supplied to H.M. War Office and Admiralty.



When Ordering
Tanks for Shipment,
Reduce
the Cost of Freight
by
specifying our make.

Light, Cheap,
Bolted Joints,
Easily Erected
Delivered From Stock,
and
the Strongest on the
Market.
Over 4,000 tons supplied.

Sole Makers : **BROWN, LENOX & CO., (LONDON), LTD., POPLAR, E.**

CABLEGRAMS ... ... "LENOX, MILLWALL." 6547

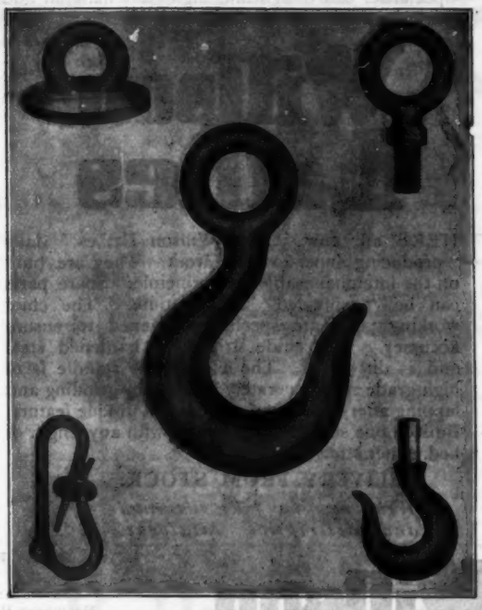
ALUMINIUM

CASTINGS OF EVERY DESCRIPTION.

BIRMINGHAM ALUMINIUM CASTING (1903) CO. LD.,
Cambridge Street Works - - BIRMINGHAM.

SAND AND DIE CASTINGS
of the Highest Quality for 7084
General Engineering,
Automobile
and
Aeronautical
Work.

BURTON, DELINGPOLE & Co



MANUFACTURERS OF

SHIPPING & LIFTING TACKLE

OF EVERY DESCRIPTION.

DROPFORGED HOOKS, EYEBOLTS, EYEPLATES, ETC., A SPECIALITY.

DROPFORGINGS ONLY OR FINISHED MACHINED TO CUSTOMERS' REQUIREMENTS.

On Admiralty and War Office Lists. | Contractors to Home and Colonial Railways.

May we quote you?

8045

HEAD OFFICES: MOSELEY STREET, BIRMINGHAM

"Telegrams:—"DELINGPOLE" Birmingham

WORKS: BIRMINGHAM & OLD HILL, STAFFORDSHIRE

Phones: BIRM.M. 2573 & 2574 Midland. OLD HILL, 142 Cradley."

THE

J. W. BARNES

PATENT

DRILL CHUCKS

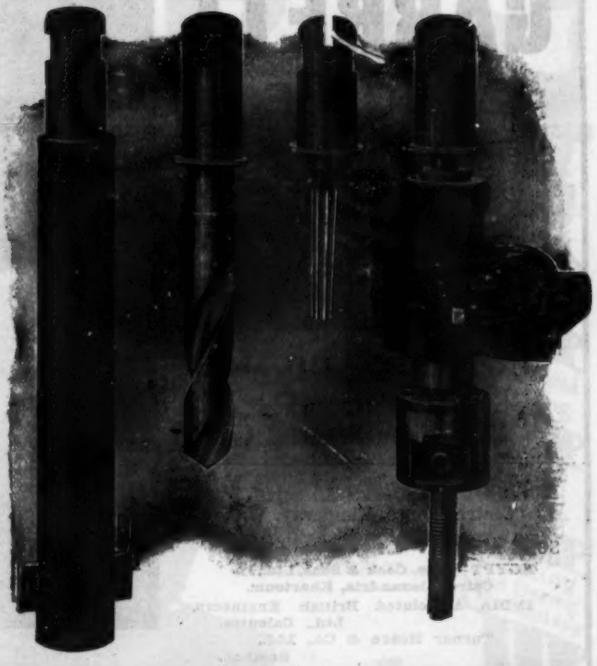
THE BEST.

Drills, Boring Bars, Reamers, Tappers, &c., changed whilst machine is in motion.

THOUSANDS IN USE.

5036

Full particulars on application to:



THOS. R. ROBERTSON,

7, Hurst Street, LIVERPOOL. M.I.Mech.E.

The 5,221st Lathe!

INSURE against large upkeep costs and short-life Machines. Every Lathe which the Willson organisation sends out embodies the best that Lathe Specialists can design and high-class material and workmanship produce.

Willson Lathes

THERE are now 5200 "Willson Lathes" daily producing super-accurate work. They are built on the interchangeable unit principle. Spare parts can be "expressed" at any time. The chief working parts are specially hardened to ensure accuracy. The guide strip is of hardened steel and is dirt proof. The Head Stop spindle is of high grade steel accurately finished by grinding and lapping after hardening. This is an unique feature. Built in one size only, 8½ centres with any length of bed, either straight or gap.

DELIVERY FROM STOCK.

Write now for fully illustrated and descriptive catalogue.

7563

Willson

(SMITH, BARKER & WILLSON & CO.),
Lathe Makers, HOLMDENE, Halifax, Eng.

Phone: 46 HALIFAX.
Grams: "LATHE, HALIFAX."

ABC Code, 5th Edition, and private code.

Showroom:
MACHINERY HALL,
68, Horton Street, Halifax.
Half-a-minute from Halifax Railway Station.

THE
GARRETT
ENGINE
FOR
FUEL ECONOMY.

In Sizes up to 400 B.HP.

LONDON OFFICE:—
Central House, Kingsway, W.C.

SOLE AGENTS:—
EGYPT—Thos. Cook & Sons, Ltd., Cairo, Alexandria, Khartoum.
INDIA—Associated British Engineers, Ltd., Calcutta.
Turner Hoare & Co., Ltd., Bombay.
STRAITS SETTLEMENTS—
The Borneo Co., Ltd., Singapore.

For all classes of Fuel.

8044

RICHARD GARRETT & SONS, Ltd. LEISTON WORKS, ENGLAND.

Salamander

Bell's non-conducting Boiler Composition

Bellbuoy

is the result of 48 years' combination of science and engineering experience in conserving costly boiler heat.

Below are shown details of two entirely independent tests which establish beyond dispute that a saving of 80% to 84% in condensation is effected by the use of Bell's Composition.

Copy of report of the Whitworth Engineering Laboratory (University of Manchester) Steam Pipe Covering Tests. Bell's United Asbestos Non-Conducting Composition.

Mean thickness of covering	2·11
Water condensed per sq. ft. of external surface of bare pipe per hour	0·8·5 lbs
Water condensed per sq. ft. of external surface of covered pipe per hour	0·162 lbs
Percentage efficiency	81

In accordance with these tests, the covering when applied to a one-inch pipe in a layer of not less than 2·11 inches thick conforms to the standard required by regulation 6 (c) of the regulations dated December 21st, 1911, made by the Secretary of State under the Factory & Workshop (Cotton Cloth Factories) Act, 1911 (12 Geo. 5, c. 21), as to humidity and ventilation in Cotton Cloth Factories.

Summary of report of tests made by Messrs. Lake & Currie, Consulting Engineers, London, with Bell's United Asbestos Non-Conducting Composition.

Mean steam pressures absolute	154
Mean steam temp. Far.	×·371°
Mean lbs. condensed by the bare pipe per sq. ft. per hour	0·9808
Mean lbs. condensed by the covered pipe per sq. ft. per hr.	0·152
Mean difference of temp. Far. of external air and steam supplied	×·284°
Mean lbs. condensed by the bare pipe per sq. ft. per hour per deg. Far. diff. of temp.	0·00337
Mean lbs. condensed by the covered pipes per sq. ft. per hour per deg. Far. diff. of temp.	0·000541
Approx. relative % condensation in bare pipe	100%
Approx. relative % condensation in covered pipe	16·9%

This equals a saving in condensation of 83%

Samples and Catalogues on application.

Bell's United Asbestos Co Ltd

Pioneers of the World's Asbestos Industry

Southwark Street, London, S.E.1.

B 9.34

SULZER BROTHERS

Centrifugal Pumps

For All Conditions and Requirements.

DIESEL Engines

Stationary and Marine

Uniflow Steam Engines and Boilers

Centrifugal PUMPS

Boiler Feed PUMPS

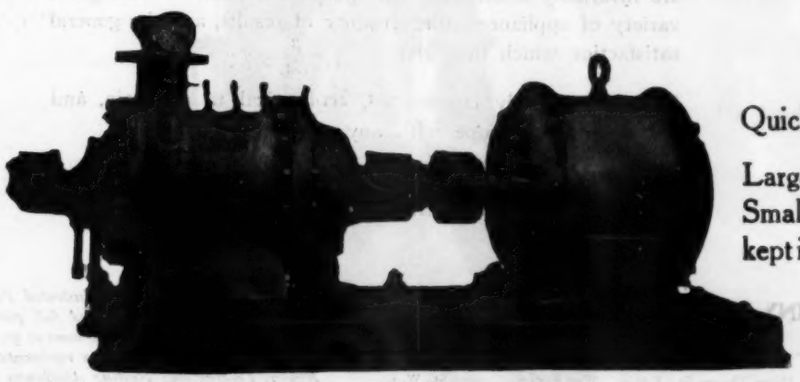
FANS

Bleaching and Dyeing Machinery

Reliable.

Simple.

Efficient.



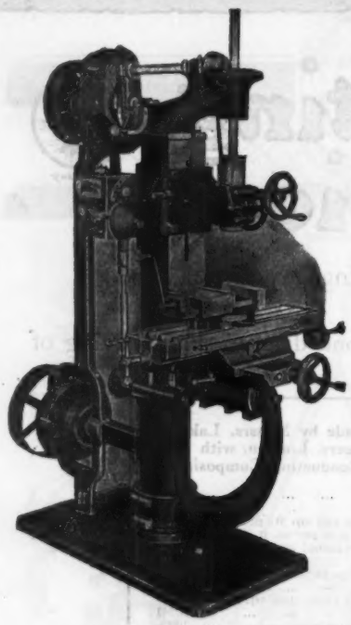
7903

Quick Delivery

Large Stock of Small Pumps kept in London.

31, Bedford Square, London, W.C. 1.

WORKS: WINTERTHUR, SWITZERLAND.



Produce! *Don't Waste Time Resetting.*

The Knight Milling and Drilling Machine is provided with a tilting table, permitting work to be handled at any angle without necessitating a resetting of the job. The adjustments are few and simple—the table may be depended upon for its steadiness in all positions.

KNIGHT MILLING AND DRILLING MACHINES

are used for surfacing work at angles, which would be awkward, if not impossible, without the Knight tilting table. Resetting time is eliminated—production spurred in consequence. The Number 2 Knight handles light and heavy work with equal convenience. It is one of four sizes—all rigid, powerful, accurate producers. We will try to give you a specific idea of what the Knight Milling and Drilling Machine will do for you, if you will tell us the nature and requirements of your work.

COATS MACHINE TOOL COMPANY, LTD.,

14, Palmer St., Westminster, London, S.W. 1. 7642

Phones: VIC. 2518 and 1509. **Telegraphic Address: "Oolcomachi, Vic., London."**

SOLE AGENTS FOR—

SHORE INSTRUMENT & MFG. CO., New York; NEW BRITAIN MACHINE CO., New Britain, Conn.; INTERNATIONAL MACHINE TOOL CO., Indianapolis, Indiana; CULFOR TOOL CO., Buchanan, Mich.; W. B. KNIGHT MACHINERY CO., St. Louis, Mo.; FISCHER MACHINE CO., Philadelphia, Pa.; HANNIFIN MANUFACTURING CO., Chicago, Ill.; MURCHEY MACHINE TOOL CO., Detroit, Michigan; MINSTER MACHINE CO., Minster, Ohio, Mo.

BY APPOINTMENT
CARRON

Increased Service in the Factory— is the natural outcome of feeding the workers

CARRON COOKING APPARATUS

(for Steam, Coal, Coke, Gas or Electricity)

are invariably selected for this purpose because of the great variety of appliances, the certainty of results, and the general satisfaction which they give.

They are strongly constructed, economical to maintain, and are designed to cope with any cooking problem.

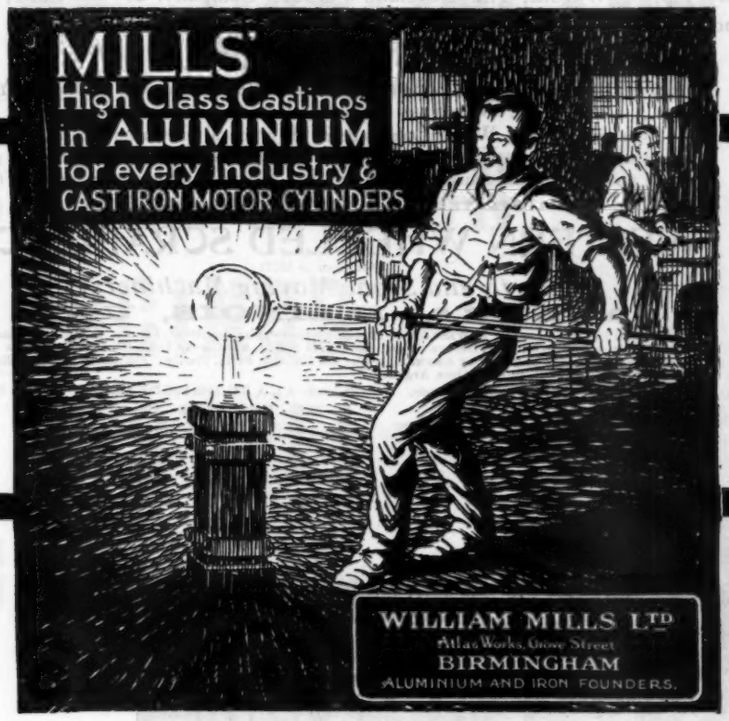
Adopted by INDUSTRIAL CANTEENS, HOTELS, RESTAURANTS, INSTITUTIONS, STEAMSHIP LINES, &c., and by H. M. GOVERNMENT.

CARRON COMPANY **Works: CARRON, STIRLINGSHIRE.**

Branch Works . . . . . PHŒNIX FOUNDRY, SHEFFIELD.

Showrooms: LONDON—(City) 15, Upper Thames St., E.C. 4; (West End) 50, Berners St., W. 1. LIVERPOOL—Redcross St. GLASGOW—Buchanan St. EDINBURGH—George St. BRISTOL—Victoria St. NEWCASTLE-ON-TYNE—Prudhoe St. BIRMINGHAM—Corporation St.

¶ *Write for No. 12L Illustrated Pamphlet, "A Touch of the Switch Does It," and full particulars, on application to the Company's Showrooms at 50, Berners Street, Oxford Street, London, W. 1, where a representative display of Carron Electric Cooking and Heating Appliances can be inspected.*



MANY years experience in the production of castings is offered to you by Wm. Mills Ltd.; if you have practical knowledge of the difficulties to be surmounted you will realise at once how valuable that experience is to you. It enables us to invite your enquiries in full confidence that we shall supply a quality of workmanship that you will find satisfactory.

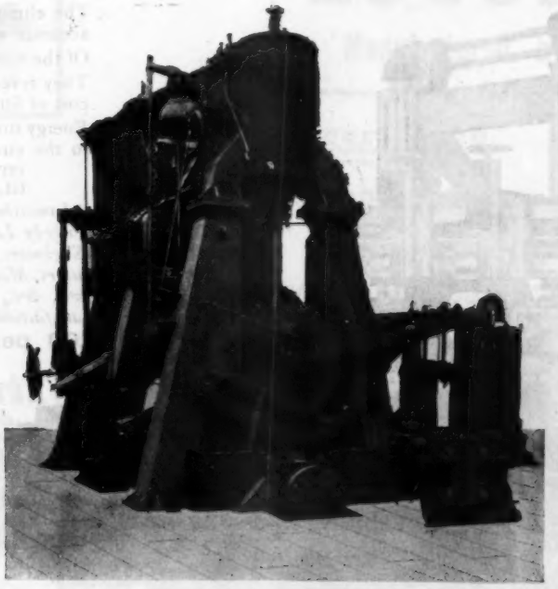
8050

McKIE & BAXTER

ENGINEERS, SHIPBUILDERS, BOILERMAKERS, COPLAND WORKS, GLASGOW.

Telegrams: "CALIDAD, GLASGOW." Codes: A 1, A B C, Engineers and Private Code.

ANNUAL OUTPUT 30,000 I.H.P.



MARINE ENGINES 5000 TO 25 I.H.P. ON ONE SHAFT.

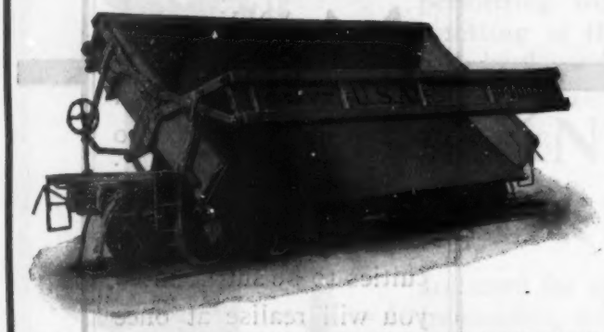
2788

SPECIALITY.—MACHINERY FOR VESSELS CONSTRUCTED ABROAD.

Correspondence Invited.

LOWER COSTS & INCREASE PRODUCTION.

Having installed 12 Western 30 cubic-yard Railway Tipping Wagons, The Cleveland Furnace Company, of Cleveland, Ohio, U.S.A., is saving the cost of one wagon each month. **These 12 Tipping Wagons will pay for themselves in 12 months.**



Western 12-yard Railway Tipping Wagon in position for discharging load (Air operated).

CONSULT OUR LONDON AGENTS

or nearest Branch House, as to the adaptability of Western Tipping Wagons to YOUR needs. Costs must be lowered and production increased, or the world is lost.

Western Tipping Wagons are made in all practical sizes from ½ cubic yard to 30 cubic yards capacity. The larger sizes are air operated, having 34 per cent. greater tipping power, with less consumption of air, than any other tipping wagon on the market.

ILLUSTRATED CATALOGUE SENT ON APPLICATION.

WESTERN WHEELED SCRAPER CO.,

(FOUNDED IN 1877)

Earth and Stone Moving Machinery, 6545

AURORA, ILLINOIS, U.S.A.

BRANCH OFFICES.—GEORGE P. WEST & Co., Iddesleigh House, Caxton Street, London, S.W. 1, England. E. D. MORRISON & Co., LTD., 257A, George Street, Sydney, N.S.W. ANDERSONS LTD., Christchurch, New Zealand. ALLIED MACHINERY COMPANY OF AMERICA, 2, Rue des Italiens, Paris, France; Fontanella, 21, pral, Barcelona, Spain; Venezuela 691, Buenos Aires, Argentina.

Cable Address—Western, Aurora, Illinois. Codes used—A 1, A B C. (4th and 5th Editions), Western Union.

Dumping Western 10-yard Tipping Wagons; installation of Oxfordshire Ironstone Co., England. Note length of train, carrying some 250 cubic yards of material. These 10-yard wagons are of especial value in foundries, steel and iron mills, &c., for moving heavy material about the yards.

Increasing Output

100 per cent. - -

LANCASHIRE

"Lancashire" Patent Electric Drive permits higher speeds and a more perfect control than can be obtained by any other system.

More than 1,000 Planers and Reciprocating Tools are now driven by this successful drive—successful because—

The elimination of slipping belts ensures more accurate work and heavier cutting.

Of the wider range of cutting speeds.

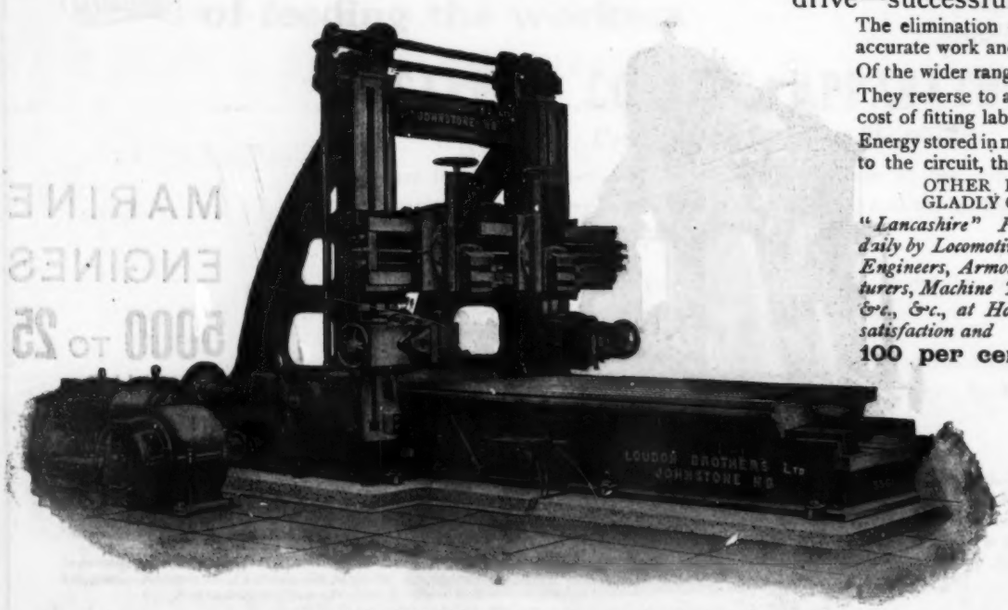
They reverse to a line on both strokes, reducing cost of fitting labour.

Energy stored in moving parts at reversal is returned to the circuit, thus reducing power consumption.

OTHER IMPORTANT REASONS GLADLY GIVEN TO ENQUIRERS.

"Lancashire" Patent Electric Drives are used daily by Locomotive Builders, Shipbuilders, Marine Engineers, Armour Plate and Ordnance Manufacturers, Machine Tool Makers, General Engineers, &c., &c., at Home and Abroad, and give entire satisfaction and

100 per cent. Increased Output.



"LANCASHIRE" EQUIPMENT on 5 ft. by 5 ft. 12 ft. "LOUDON" PLANER: Cutting speeds, 25 to 98 f.p.m.; Return speeds, 120 to 196 f.p.m.

THE - - 7491

Lancashire Dynamo & Motor Co.,

LIMITED.

Trafford Park, MANCHESTER.

Tele.: City 7450 (6 lines).
Telegrams & Cables: Ironclad, Manchester.

THE DARLINGTON FORGE LTD.,

Telegrams: "Forge, Darlington." DARLINGTON, ENGLAND. Telephone: No. 2610.

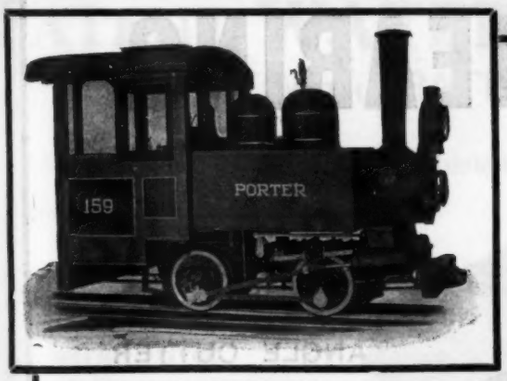
STEEL & IRON FORGINGS, STEEL CASTINGS.

3-THROW MILL ENGINE CRANKSHAFT.
23 in. diam. by 31 ft. 6 in. long. Finished Weight, 40 tons.

Up to any size or weight.

REPAIR WORK A SPECIALITY.

7654



PORTER LOCOMOTIVES

Manufactured by the H. K. PORTER CO.

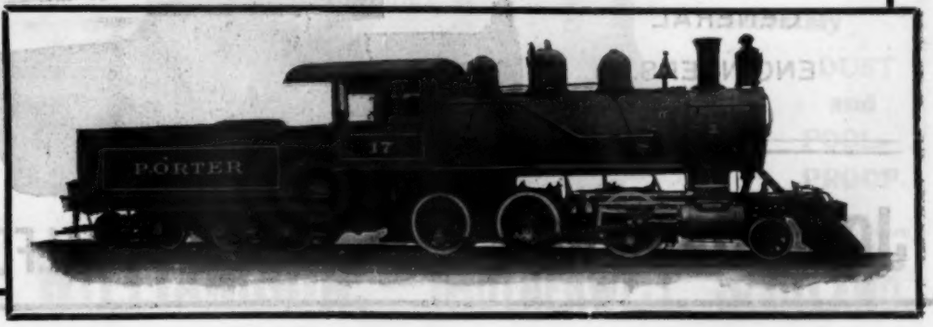
SPECIAL DESIGNS for:

Main Line Passenger and Goods Traffic,
Steel and Iron Works,
Quarries,
Phosphate and other Mines.
Manufactories and other Industrial Service,
Coke Ovens,
Contractors and Public Works,
Logging Railways,
Street and Suburban Railways, etc.

COMPRESSED AIR for UNDERGROUND MINE HAULAGE.

FIRELESS for VARNISH WORKS, POWDER MILLS, Etc.

We have UNUSUAL facilities for turning out COPPER FIRE BOXES to any drawing.



Sole Export Agents:
WONHAM, BATES & GOODE, INC.,
17, Battery Place, NEW YORK. 3, London Wall Bldgs, LONDON, E.C. 2.
and at
PARIS, HAVANA. GENEVA, MONTREAL.
RIO DE JANEIRO. 7889

Tullis
LEATHER BELTING

"Built up to a Standard,
NOT
Down to a Price."

80 years' experience is behind "Tullis."

"A BELT FOR ANY DRIVE." 7413

JOHN TULLIS & SON LTD.,
ST. ANN'S WORKS, GLASGOW.

ESTABLISHED 1834

PUNCHING AND SHEARING
MACHINES.

As supplied
to
SHIPBUILDERS,
BOILERMAKERS,
CONSTRUCTIONAL
and
GENERAL
ENGINEERS.

With
ANGLE CUTTER
LIMBER PUNCH
NOTCHER
CRANES
for BELT or
DIRECT MOTOR
DRIVE.

JOHN CAMERON LD. 7215 SALFORD, MANCHESTER.

We had to Move

owing to the extension of our business. We have built and equipped the largest and finest works in the world for the special manufacture of

Metallic Packings.

Our productions are known wherever steam engines are used. We don't make **THE CHEAPEST** packing—true economy does not lie in that direction—but we make **THE BEST.** Engineers appreciate this. We have fitted our system to over **280,000** stuffing boxes, and have had to increase the size of our works to meet the demand for more. If you are in the market we shall be glad to hear from you, at our new address:—

THE UNITED STATES METALLIC PACKING CO., LTD.,

Soho Works, Allerton Road, BRADFORD, Yorks.

Telegrams: METALLIC, BRADFORD. 7816 Telephones: Nos. 4705, 4706.

Branch Offices—LONDON: 110, Fenchurch St. LIVERPOOL: 15, Fenwick St. GLASGOW: 52, St. Enoch Sq. NEWCASTLE-ON-TYNE: 2, Collingwood St. SHEFFIELD: 24, Norfolk Row. BOLTON: 15, Mawdsley St. SWANSEA: Angel Chambers, York St.

PATENT WATER-DRIVEN CENTRIFUGALS

WITH PATENT INTERLOCKING GEAR.

Awarded GOLD MEDAL at Brussels Exhibition.

Also

Belt and Electric-Driven CENTRIFUGALS.

HYDRO-EXTRACTORS for Chemical Works and Laundries.

CRYSTALLISERS, CONVEYORS, ELEVATORS.

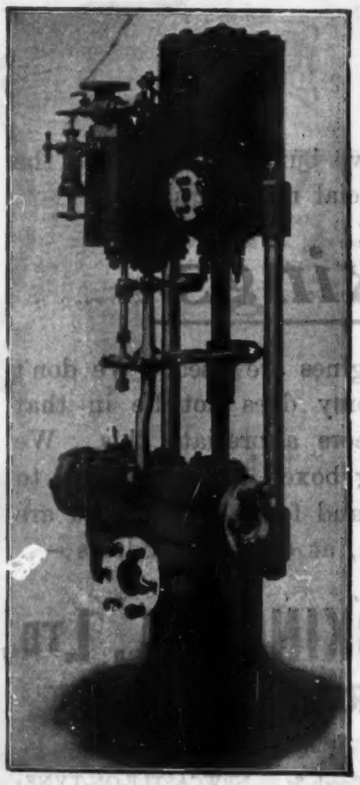
Write for particulars of our new

CENTRIFUGAL SPINDLE BEARING,

the simplest and most efficient on the market. **Runs in Oil; absolutely DUST and FOOL-PROOF.**

7921

POTT, CASSELS & WILLIAMSON, MOTHERWELL, SCOTLAND.



BOILER FEED PUMPS

The Ideal Pump for Boiler Feeding.

Unrivalled for Efficiency & Economy.

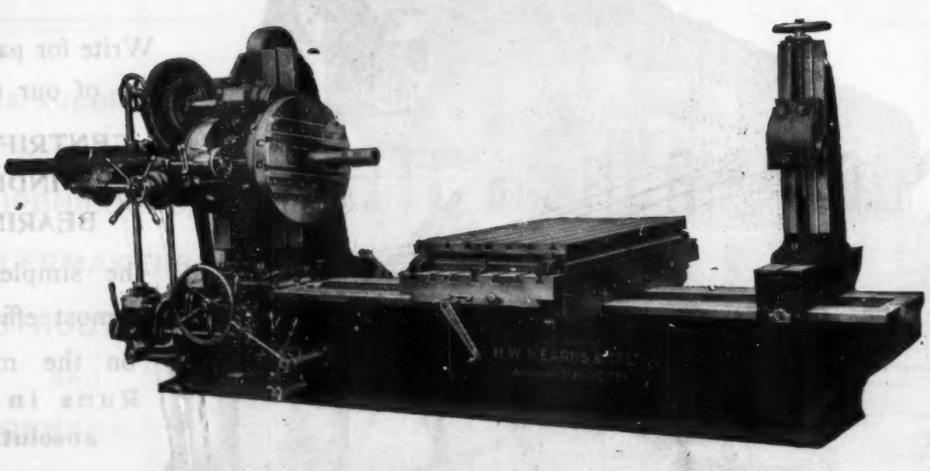
Thousands at work.

Delivery from Stock.

J. P. HALL & SONS,
LIMITED,
PETERBOROUGH.

0138

KEARNS *For Horizontal Boring Machines.*



"KEARNS PATENT"

Combining Automatic Facing with Traversing Spindle.

Made in 5 sizes, with or without Traversing Spindle.

Our Machines are absolutely universal. Consult us before purchasing other Machine Tools.

WRITE FOR CATALOGUE.

TEST PIECE WITH EVERY MACHINE.
Positive Proof of Accuracy.

FRANCE.—Societe Anonyme Alfred Herbert, 47, Boulevard de Magenta Paris.
SPAIN & PORTUGAL.—Societe Anonyme Alfred Herbert, 270 Calle de Mallorca, Barcelona.
BELGIUM.—Limbourg Freres, 34, Rue Plantin, Brussels.
ITALY.—Societa Anonima Italiana Alfred Herbert, 42, Via Cajazzo, Milan.
JAPAN.—Alfred Herbert Ltd., 14, Yamashiti-cho, Yokohama.
UNITED STATES.—Alfred Herbert Ltd., 34, Dey Street, New York.
AUSTRALIA.—Benson Bros., 51-53, Druitt Street, Sydney.
INDIA.—Alfred Herbert Ltd., 13, British India Street, Calcutta.

4815

H.W. KEARNS & CO LTD BROADHEATH. NR MANCHESTER

THE BUTLER SLOTTER LEADS

Tel. Address:
BUTLER, HALIFAX.
Telephone No. 1013.

J. BUTLER & CO., VICTORIA IRON WORKS, HALIFAX.

ESTABLISHED 1868.

8446

Specialists in Reciprocating Machine Tools, Planers, Slotters & Shapers.

THE SCOTTISH TUBE CO., LTD.

Head Office: 34, Robertson Street, GLASGOW.

BRANCH OFFICES—LONDON, MANCHESTER, LIVERPOOL, NEWCASTLE-ON-TYNE, CARDIFF, SYDNEY, WELLINGTON, N.Z., JOHANNESBURG.

WORKS—GLASGOW, GOVAN, COATBRIDGE, RUTHERGLEN and GARNKIRK.

MANUFACTURERS OF:

WROUGHT-IRON AND STEEL PIPES.

7779

BOILER TUBES

Transporting Galvanized Water Pipes in the Salt Suan Country, Australia.

Gas, Water, and Steam TUBES and FITTINGS.

Boring and Casing TUBES.

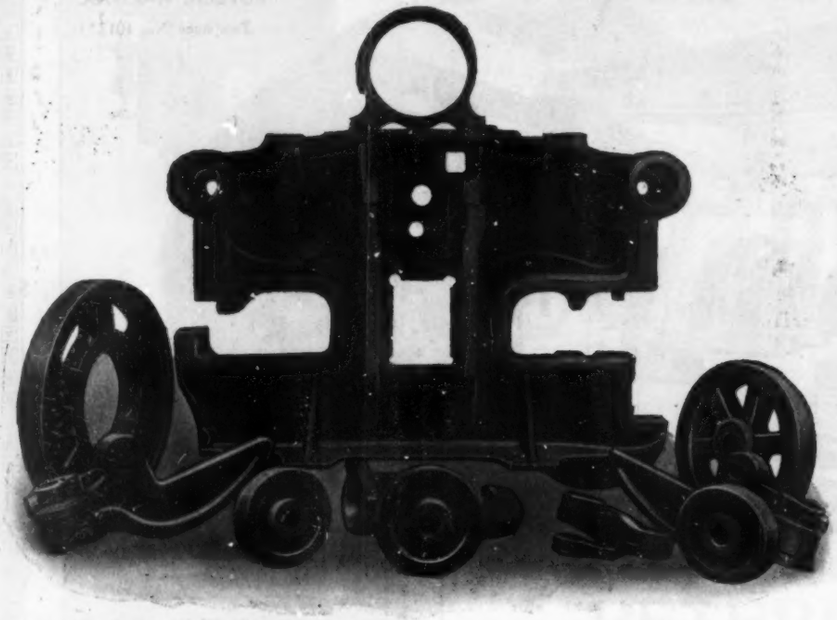
PIPES for Welding into Continuous Mains. 7773

Telephone—No. 5687 CENTRAL (Six lines).

Telegraphic Address—SCOTUBECO, GLASGOW.

Codes—A 1, A B C (4th and 5th Editions), Liebers, Western Union, and Private.

STEEL CASTINGS



Group of Electric Steel Castings for Riveting, Punching and Shearing Machinery.
The Main Frame weighs 4 tons, 10 cwts. 7967

OF THE HIGHEST QUALITY, FOR ALL PURPOSES AND OF ALL DESCRIPTIONS, UP TO

4½ TONS EACH.

EVERY UP-TO-DATE ENGINEER

KNOWS

that for whatever purpose steel may be required

ELECTRIC STEEL

IS THE

BEST OBTAINABLE.

We are the Pioneers of Electric Steel in Heavy Commercial Steel Castings, and all our Steel is made in the most Modern Electric Furnace.

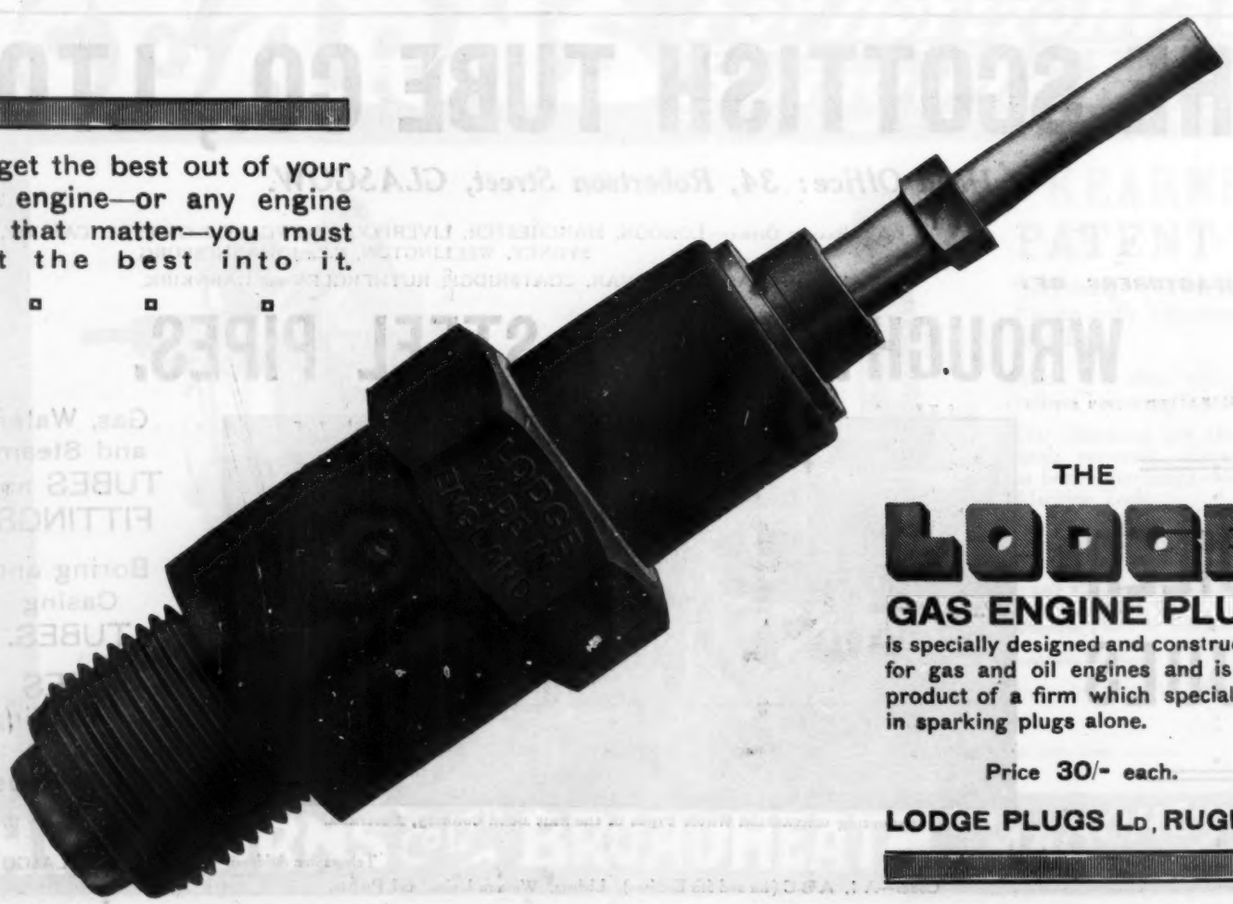
'Phone:— { 741 SUNDERLAND. / 742 „

Telegrams:—"CASTINGS, SUNDERLAND."

ESTABLISHED - - - - - 1821.

E. JOPLING & SONS, Ltd., PALLION STEEL WORKS, SUNDERLAND.

To get the best out of your gas engine—or any engine for that matter—you must put the best into it.



THE

LODGE

GAS ENGINE PLUG

is specially designed and constructed for gas and oil engines and is the product of a firm which specializes in sparking plugs alone.

Price 30/- each.

LODGE PLUGS LD, RUGBY.

Concerning Welding Efficiency.

¶ No announcements made in the trade journals during recent years have had a tithe of the importance attaching to those made by Picketts Limited, in respect of the revolution in welding practice created by the introduction of Certified "Armco" Ingot Iron Welding Rods. These incomparable rods have simplified the task of the welder and provided him with a standardised single composition in two tempers for Electric and Oxy-Acetylene equipment, can be used with *existing* equipment, and do better what has heretofore required a choice of one of many grades. Wherever introduced they are enthusiastically welcomed. The proof is easy—try them ; once used, they are always used. They stand for dependable work, eliminate blow-holes, slag-inclusions, and other imperfections. You will be surprised at their wonderful purity, ductility, and toughness. Ask the man who has used them.

¶ The whole story of the great record achieved by Certified "Armco" Ingot Iron Welding Rods, together with full analysis and particulars of rigorous tests is told in the "ARMCO" WELDER BOOKLET. Write for it to-day—sent post free on request.

PICKETTS LIMITED,

MORTIMER WORKS, HOVE——SUSSEX.

Telephone : Hove 3072. Telegrams : "Picketts, Hove."

London Office: 8, Broad Court Chambers, Bow Street, W.C. 2.

Telephone : Gerrard 6281. Telegrams : "Picketts, Expresseth, Rand, London."

'ARRIS.—What yer looking so blue about? You can get on with the job now they've sent us this 'Zenith' Winch, there'll be no more breakdowns.

THE BRITISH STEEL PILING CO., DOCK HOUSE, BILLITER STREET, LONDON, E.C. 3.

"The WINCH that NEVER fails."

FRICTION CLUTCHES
FRANK WIGGIN & SON LTD
SHAFTING
GEARING
BELT & ROPE PULLEYS
SHIPLEY

FORGINGS IN STEEL AND IRON

N. HINGLEY & SONS LD

NETHERTON IRON WORKS.

7679

DUDLEY.

FEDERAL BALL BEARINGS
FOR ALL COMMERCIAL PURPOSES.

These bearings are used on—

Auto Radiator Fans Baby Coaches Bicycles Blowers Carpet Sweepers Casters Ceiling Fans Cream Separators Door Hinges Electric Fans Filing Cabinets Gas Engines Grindstones Motors Magnetos Mowers Machinery of all Kinds Pulleys Speedometers Timers Tricycles, etc. Trolley Wheels Trucks Vacuum Cleaners Washing Machines Wringers

7465

WRITE FOR PRICE LIST TO
Sole Agents for the United Kingdom—
STANLEY J. WATSON,
BERNERS WORKS,
87, Sheen Road, Richmond,
London, S.W. 14.

Telephone—1782 & 1783 RICHMOND, SURREY.
Telegrams—SOUVILLON, RICHMOND, SURREY.

AMSLER BROTHERS, SCHAFFHOUSE, SWITZERLAND.

Makers of all classes of Precision Instruments.

Stress Recording Apparatus.

Extensometers and Compressometers.

Standardising Boxes for Testing Machines.

Pressure Gauge Testers up to 1000 atmospheres.

Martens' System of Mirror Cathetometer.

Pendulum Dynamometers, for accurately measuring the loading of hydraulic testing machines.

The study and construction of machines to make special tests is willingly undertaken.

Makers of all sizes of Universal Testing Machines, from 10 to 250 tons.

Specially designed horizontal machines, for Cable and Chain Testing.

Compact self-contained machines for making Abrasion, Repeated Impact, and Alternating Stress Tests.

Torsion Testing Machines, both simple, and combined with Tension or Compression Tests.

Write for full particulars to 7714

T. J. PRIMROSE,
162, NORWICH ROAD, IPSWICH.
(SOLE AGENT FOR GREAT BRITAIN.)

THE AIROSTYLE SYSTEM of PAINTING

LET THE AIROSTYLE SYSTEM TAKE ITS MERITED PART IN YOUR RECONSTRUCTION PLANS.

OF EQUALLY GOOD SERVICE IN PEACE AS IN WAR.

EFFECTS OVER 75% SAVING ON PAINTING COSTS

MANUFACTURED THROUGHOUT BY THE
AIROSTYLE & LITHOS LTD.
ENGINEERS.
35, ST. BRIDE STREET, LONDON, E.C. 4.
Telegrams "AIROSTYLE, FLEET, LONDON" CONTRACTORS TO ADMIRALTY, MINISTRY OF MUNITIONS, &c. Telephone 2262 CENTRAL.

LET US SHOW YOU HOW TO ADAPT YOUR EXISTING WAR SERVICE AIROSTYLE PLANT TO MEET YOUR PEACE REQUIREMENTS

6868

Telegraphic Address—"Clyde, Hallside, Lanarkshire." Telephone—17 Cambuslang (2 lines).

"CLYDE" DOGS

"CLYDE"

"CLYDE"

Largest British Shippers of all kinds of Nails, Tacks, and Spikes.

"Scottie."

Sole Makers of "CLYDE" DOGS.

7643

RELIABLE BRITISH DOGS.

CLYDE NAIL CO., LTD. Works: NEWTON, Near GLASGOW.
London Agents—GILLESPIE & MAYHEW, 14/15, Billiter Buildings, Billiter Street, London, E.C. 3.

Telephone: No. 296 Smethwick (4 Lines).
Telegraphic Address: "Carriage," Smethwick, Birmingham.

THE

Grand Prix,
Buenos Ayres Exhibition, 1910.

BIRMINGHAM

RAILWAY CARRIAGE AND WAGON CO., LTD.,

FOR HOME — SMETHWICK. — AND ABROAD.

MANUFACTURERS OF

RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION, INCLUDING ALL-STEEL CARRIAGES.

6981

PRESSED STEEL UNDERFRAMES, BODIES AND BOGIES.

MAKERS OF RAILWAY WHEELS AND AXLES, IRONWORK, AXLE BOXES, CASTINGS, &c.

Sole Manufacturers of Dean & Churchward's Patent "Eitherside" Brake, and Marillier's Patent "Instanter" Coupling.

PENMAN & Co LTD.

6479

CALEDONIAN BOILER WORKS, GLASGOW.

TELEGRAMS:—
DOUGLAS, KIRKCALDY.
CODES:—
A 1.
A B C, 5th Edition.
ENGINEERING.

'PHONE:—
105, KIRKCALDY
(2 lines).

WE MANUFACTURE
ALL CLASSES OF MACHINERY
FOR

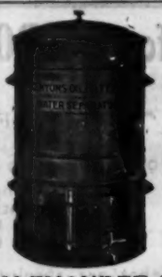
DOCKYARDS & SHIPYARDS.

MARINE ENGINES & SHIPS' MACHINERY.

Repairs Executed Afloat or Ashore.

DOUGLAS & GRANT, Ltd.,

KIRKCALDY, SCOTLAND. 6653



KENYON'S PATENT OIL FILTER AND WATER SEPARATOR.

Over 900 ordered by H.M. Government.

ENGINEERS' STORES TOOLS.

ALEXANDER KENYON & CO.
Victoria Bridge, MANCHESTER. 8009

STAMPINGS

ANY WEIGHT. 7334
IN ANY STEEL.
FOR ALL PURPOSES.

HEAVY STAMPINGS LTD.,
MIDDLESBROUGH.
TELEGRAMS—STAMPINGS. TELEPHONE—321.
LONDON OFFICE: 71, Southwark Street, S.E. 1.
TELEPHONE—Hop. 2746 and 4381.

Feed Water Heaters.

ALL KINDS FOR Exhaust & Live Steam.

POLLOCK, MACNAB & 7103 HIGHCATE
Shettleston,
GLASGOW.

G. & A. HARVEY, LTD.,
GOVAN, GLASGOW, W.

MAKERS OF

HIGH-CLASS MACHINE TOOLS.

PROMPT DELIVERY. 7236
CATALOGUE ON APPLICATION.

See our Illustrated Advt. in next week's issue.

R. B. LINDSAY & Co.
38 MAIR ST PLANTATION GLASGOW

FOR ALL STEAM PRESSURES
TEL. CONICAL GLASGOW

PATENT COMICAL
ENGINE PACKING

GALVANISED CORRUGATED SHEETS.

MERCURY BRAND.

(BEST AND CHEAPEST.)

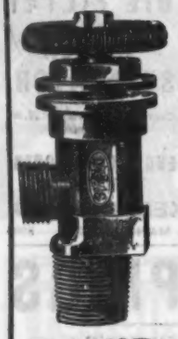
Send us your enquiries. Thick gauges and all difficult Corrugations as used for—

COLLIERIES, CONSTRUCTIONAL ENGINEERS,

A Speciality. Also Galvanised Ridges, Louvre Blades, Rivetted Galvanised Pipes for Colliery Ventilator Shafts, &c., &c.

RAMSHAY & MARSHALL, Ltd.
BIRMINGHAM. 4188

VALVES for CARBONIC ACID BOTTLES



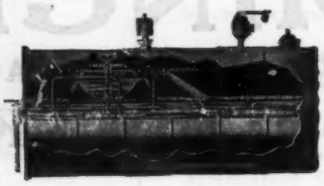
TWENTY-FIVE YEARS' EXPERIENCE, backed up by modern methods, enables me to offer VALVES for:—

Oxygen, Hydrogen, and Coal Gas Bottles,
Carbonic Acid Bottles,
Nitrous Oxide Bottles,
Sulphurous Acid Bottles,
Ammonia Bottles,
Chlorine Bottles,
Refrigerating Plant, 8127

that are absolutely reliable. Valves are all made from Drop Steel or Brass Forgings (not Castings, as very often employed), and are guaranteed to have been efficiently tested under gas pressure before despatch from my works. I invite enquiries and correspondence, which shall have my best attention at all times.

DAVID SCOTT, CATHKIN ENGINEERING WORKS, POLMADIE, **GLASGOW.**

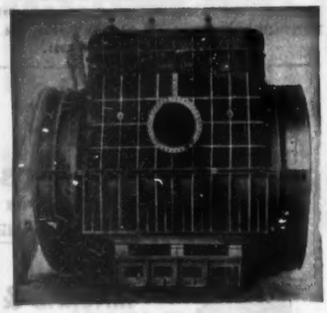
Tranter's Improved Feed-water Detartarizer



Boiler Disincrustants.
Boiler and Pipe Coverings
(Magnesia, Asbestos, Fossil Meal, &c.)
Lubricating Oils and Greases.
Soluble Oil & Cutting Compounds.

W. J. TRANTER, LIMITED,
Tibbington Works, Princes End, TIPTON, Staffordshire. 7327
Telephone—16 Tipton. Established 1890. Telegrams—"Titan, Tipton."

WHEELER CONDENSERS
ARE BUILT IN ALL SIZES AND TYPES.



Wheeler Surface Condenser of 50,000 sq. ft. Tube Surface, serving a 30,000 Kw. Steam Turbine.

THE accompanying shop photograph shows a unit for a 30,000 Kw. turbine. Special attention is given to the spacing and arrangement of tubes in these condensers, so as to insure minimum pressure drop or loss of vacuum between exhaust inlet and air pump outlet.

WHEELER CONDENSER & ENGINEERING CO.

Main Office and Works—
Woodbridge Av., Carteret, New Jersey, U.S.A.
Manufacturers of High Vacuum Surface Condensers High Vacuum Jet Condensers, Wheeler Turbo Air Pumps, Wheeler-Edwards Air Pumps, Wheeler Rotative Dry Vacuum Pumps, Centrifugal Pumps, Evaporators, Forced Draft and Natural Draft Cooling Towers, Wheeler Crescent Brand Brass and Copper Tubes and Pipe, Wheeler Crescent Brand Admiralty Mixture and Muntz Metal Condenser Tubes.

European Representative—
Les Etablissements A. W. FIDWELL,
19, Boulevard Malesherbes (Paris VIII E),
Paris, France.

London: 7309
Westinghouse Building, Norfolk Street, Strand.
Yokohama, Melbourne, Shanghai.

The BRADLEY 3-ROLL MILL
The 20th Century Marvel for Grinding—

PHOSPHATE ROCKS,
LIMESTONE, COAL,
PORTLAND CEMENT,
ORES of all kinds.

REQUIRES NO AUXILIARY APPARATUS FOR FINISHING PRODUCTS.

SATISFACTION GUARANTEED.

Full particulars on application to— 4513

BRADLEY PULVERIZER CO.,
37, WALBROOK, LONDON, E.C. 4.

ARMSTRONG COMBINATION KITS.

Made up of Tools of Armstrong Manufacture into Four Sets.
One of these will suit your needs!

Our CATALOGUE No. 14, lists each outfit, giving sizes of tools, weight of complete kits, &c. The Catalogue is yours if you —— ask for it. ——

MADE UP AS FOLLOWS—
One Genuine Armstrong Stock and Dies ¼ to 1 in. R. or L.;
One Model B Pipe Cutter;
One Junior Hinged Pipe Vice;
One Stillson Pipe Wrench.
All put up in a Hardwood Box.

7391

THE ARMSTRONG MFG. CO., 333, Knowlton Street, BRIDGEPORT, CONN., U.S.A. | NEW YORK Office: 248, Canal Street.

ORIENTAL

SEAMLESS STEEL TUBE

The Engineer who takes a pride in turning out work which he honestly believes to be as near perfection as possible—recognises that he can only be satisfied with the best material available, entirely dependable and which will recompense him for the skill and craftsmanship he is putting into the job in hand. ORIENTAL TUBES are ALWAYS dependable and will prove satisfactory under all conditions.

THE ORIENTAL TUBE CO., Ltd.,
WEST BROMWICH, BIRMINGHAM.
Telephones: West Bromwich 45 and 166.
Telegrams: "Tubes, West Bromwich."

7341

SEAMLESS STEEL TUBES

UNIVERSAL & CUTTER GRINDING MACHINE.

For ACCURATE GRINDING to size, Arbors, Spindles, Gudgeon Pins, Milling Cutters, Reamers and small tools generally.

ALSO

TAPER & INTERNAL GRINDING.

Maximum distance between centres	16½ ins.
Height from table to centres	4½ ins.
Traverse of Table	15 ins.
Traverse of Cross Slide	5½ ins.
Spindle Head rises or falls	6 ins.
Length of Internal Grinding Spindle from bearing	4½ ins.

INDISPENSABLE to machine shop or tool room. The simplicity of design enables them to be operated by comparatively unskilled labour, and they can do the work of machines costing four times the price and requiring skilled labour to operate.

PRICE MODERATE.

MORTON & WEAVER, Cox Street, COVENTRY.
Telephone 983. Telegrams—"Precision," Coventry.

BUCYRUS CO., Sth. Milwaukee, U.S.A. (Authorised Capital 10,000,000 / Paid up ditto $8,000,000)

STEAM SHOVELS (Steam and Electric)

77 BUCYRUS SHOVELS WERE EMPLOYED IN DIGGING THE PANAMA CANAL.

Spare Parts for Shovels Stocked in London. 7913

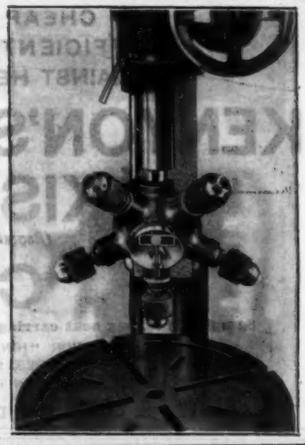
Drag-Line Excavators. River and Harbour Dredgers. Gold Dredges

Sole British Agency, GEORGE F. WEST & CO., Iddesleigh House, Caxton St., London, S.W.

THE
FORTIN TURRET HEAD
(PATENT OCT. 29, 1918.)

Will Drill, Ream, Counterbore and Spot-Face Without Moving Your Work.

This simple 5-Spindle Turret Drilling Head saves much time where tools of various sizes are used on the same piece. Takes but little more room than a chuck and is indexed very quickly by simply pressing lever at the front. Simple, compact and strong. Made in 5 sizes up to 2-inch drill.



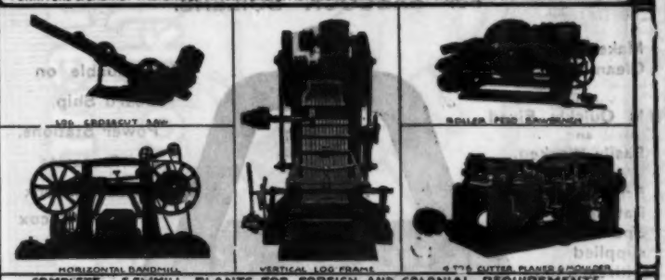
Carried in Stock by—
BUCK & HICKMAN, LONDON. 7930

Write to-day for full information and prices:

SPAFFORD TOOL WORKS,
Hartford, Conn., U.S.A.

Cable Address: "SPAFTOOL, Hartford, Conn."

SAWMILL & WOODWORKING MACHINERY
FOR SAW, PLANING & VENEER MILLS, SHIPYARDS, DOCKYARDS, ARSENALS, RAILWAY CAR & WAGON SHOPS, FURNITURE & CABINET FACTORIES, PATTERN SHOPS, MOTOR CAR & AEROPLANE WORKS, WHEEL & CARRIAGE WORKS &c.

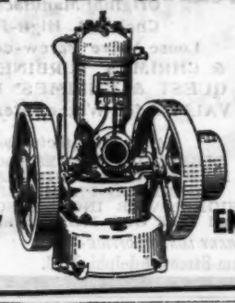


COMPLETE SAWMILL PLANTS FOR FOREIGN AND COLONIAL REQUIREMENTS
MACHINERY FOR PLYWOOD, COOPERAGE AND WOOD PULP MILLS.
JOHN PICKLES & SON, HEBDEN BRIDGE.
CATALOGUES ON APPLICATION - STATE REQUIREMENTS - 4 YORKS
CONTRACTORS TO THE ADMIRALTY, WAR OFFICE, CROWN AGENTS, INDIAN RAILWAYS &c.

HAMWORTHY
OIL ENGINES

Stationary,
Semi-Portable,
and Portable Types.

EVERY ENGINE FULLY GUARANTEED.



Work on Paraffin.
EASILY STARTED.
2½, 5 and 9 B.HP.

ELECTRIC LIGHTING AND POWER PLANTS. 7977

THE HAMWORTHY ENGINEERING Co. LTD,
76, Victoria Street, LONDON, S.W. 1.
Works: POOLE, DORSET.

SEALOCRETE
CONCRETE HARDNER (Regd.)

makes concrete floors wearproof, greaseproof, dustproof & fireproof.

It is a hardener, binder and filler of uniform quality and composition, the quality and thorough efficiency of which are guaranteed by exacting laboratory tests and a special process of manufacture, which eliminates all foreign matter.

The result is that Sealocrete is a pure hardener with 100% hardening qualities. 9857

On thousands of yards of important flooring SEALOCRETE has proved itself to be a perfect material for resisting exceptionally heavy traffic, and preventing concrete from dusting.

SEALOCRETE GREY.
For floors subjected to heavy traffic, such as Factories, Power Houses, Machine Shops, Garages and other industrial buildings.

SEALOCRETE RED.
For kitchen floors, scullery floors and walls, and for use in place of tiles, being much cheaper and more durable. Wears like steel.

ROWSE & COMPANY, 1, Dawson Street, Whitechapel, Liverpool.

Procurable only from Sole Proprietors.

Our Contract Department are experts in laying floors by our method, and we shall be pleased to promptly quote you upon receipt of your enquiries.

STANDARD CABLE CONNECTIONS
SPLIT TYPE (BRASS).

E 97.

Made in all sizes from 10 to 600 Amps.

MANUFACTURED BY:—
E. SHOWELL & SONS, LTD.,
STIRCHLEY, BIRMINGHAM.

Sole Agent for Electrical Trade:—
LIONEL ROBINSON, 3, Staple Inn, LONDON, W.C.
Telephone: HOLBORN 6323. 7859

SEND FOR A SAMPLE
OF
"Powerite"
THE BEST
Steam Jointing Known.

An accumulation of experience with other Jointings has produced POWERITE, a black steam jointing of SUPER strength. POWERITE shuts out all the old element of failures and embodies every possible improvement. POWERITE NEVER burns or blows out, and constant renewals are unnecessary. Test sample offered. 8013

— Agents wanted where not represented. —

Write
The "Powerite" Steam Jointing Co., Ltd.,
16-17, Devonshire Square, London, E.C. 2.

8-Ton Road Roller.

MOTOR ROLLERS.
1½ to 14 tons.
PETROL OR PARAFFIN

Hundreds requisitioned by the Allies during the War.

LARGE OUTPUT.
QUICK DELIVERIES. 7886

BARFORD and PERKINS, Ltd.
PETERBOROUGH.

GREAVES-ETCHELLS
Electric Furnace

is a combination Arc and Resistance Furnace. The heat is applied both above and below the charge; the effect of this is to save rabbling, ensure quick melting and a most uniform quality of steel.

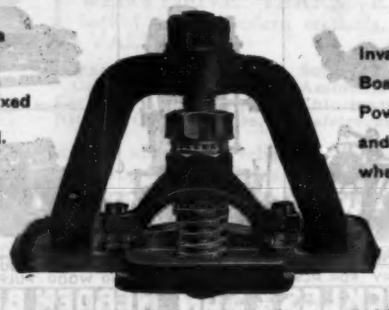
The Greaves-Etchells Furnace is simple, highly efficient and is recognised by competent judges to be the Furnace that gives the best results.

Used by the World's Leading Steel Makers.

THE CHEAPEST AND BEST METHOD OF MAKING STEEL CASTINGS. 7792

T. H. WATSON & CO. (of Sheffield), Ltd.,
NEEPSEND, SHEFFIELD.
Telegrams: "Cargo, Sheffield." Telephone No. 1682 (3 lines)

SIMPLEX HEADER FACER
For BABCOCK BOILERS.



Makes a True Clean Face.

Is Quickly Fixed and Easily Worked.

Free Wheel Ratchet Spanner supplied with each tool.

Invaluable on Board Ship, Power Stations, and Factories where Bab ock and Wilcox Boilers are used.

7987

BROMELL PATENTS Co LTD 64, DARNLEY STREET, GLASGOW.

A CHEAP YET MOST EFFICIENT INSULATOR AGAINST HEAT RADIATION

KENYON'S SPECIALLY COMPOUNDED
"KISOL"
(Registered)
CEMENT

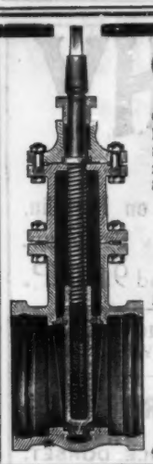
Sample 1 cwt. bag sent carriage paid for 12s. 6d. to any address.
ASK FOR "HINTS" ON COVERING STEAM PIPES, BOILERS, &c. : : 2011
Post Free on Application.

WM. KENYON & SONS, LTD., DUKINFIELD, NEAR MANCHESTER.

THE NORTH-EUROPEAN TRADING CO., Ltd.
Head Office: REGERINGSGATAN 5, STOCKHOLM. Telegrams: "ABNEKO."

Export Agents of the largest Swedish Factories of

Pocket Knives, Razors, and all kinds of Fine Cutlery;
TABLE, KITCHEN, and TOILET ENAMELLED STEEL HOLLOW-WARE;
Mining Lamps, Blow Lamps, Brazing Lamps;
PETROL COOKING STOVES; 7855
Swedish Tools of all kinds: HIGH-QUALITY.

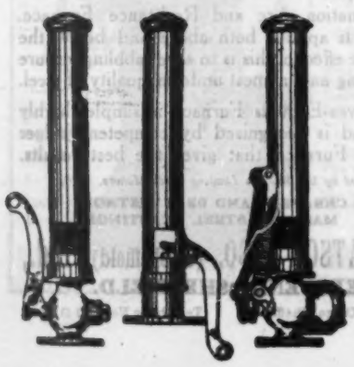


GUEST & CHRIMES, Ltd.,
On Admiralty, War Office, and Crown Agents' Lists.
GUEST & CHRIMES' IMPROVED SLUICE VALVES for Water, Steam, Sewage & Gas.
Telephone 205. Rotherham.
Telegrams—Guest, Rotherham.
Established 1840.
Original Manufacturers of Chrimes' High-Pressure Loose Valve Screw-down Cocks.
GUEST & CHRIMES' TURBINE WATER METERS.
GUEST & CHRIMES' IMPROVED SLUICE VALVES for Water, Steam, Sewage and Gas.
Also Manufacturers of—
RESERVOIR VALVES and FITTINGS.
FIRE EXTINGUISHING APPARATUS.
GENERAL PLUMBERS' GOODS. 6233
HIGH-POWER INCANDESCENT LAMPS.
WET and DRY GAS METERS and GAS FITTINGS.
TEMPORARY LONDON OFFICE: 4 & 5, Adam Street, Adelphi, W.C.
REPRESENTATIVE: Mr. Gamble Wood.

PHONE: CENTRAL 3220
CORROSION
TELEGRAMS: "WINDTIGHT."
PITTING AND SCALE
CAN BE PREVENTED IN CONDENSERS, HEATERS, ETC.,
BY INSTALLING
THE "HARRIS-ANDERSON" ELECTRICALLY AUGMENTED PROTECTIVE SYSTEM. 8084
WRITE FOR PARTICULARS TO
THE HARRIS PATENT FEED WATER FILTER (1910) LTD.,
24 GRAINGER STREET WEST.
NEWCASTLE-ON-TYNE.

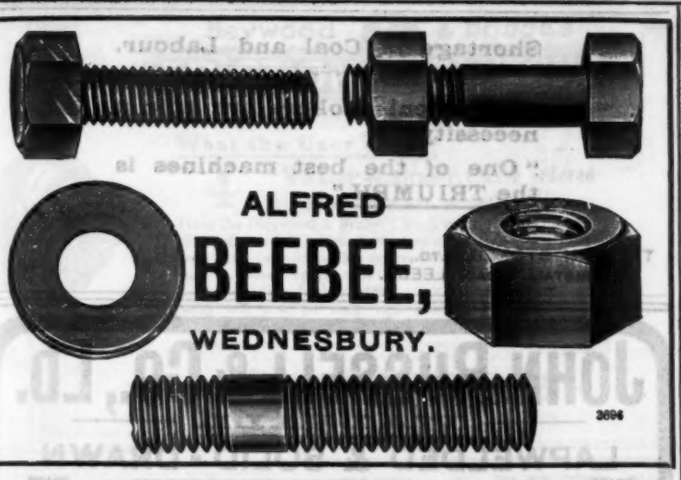
CHADBURN'S
"FLASH-LIGHT"
TORSION METERS
7406
BEVIS & GIBSON'S PATENT.
For full particulars apply—
Chadburn's (Ship) Telegraph Co., Ltd.
Cyprus Road,
BOOTLE, LANCS.

FRANCE & MORGAN,



MAKERS OF EVERY DESCRIPTION OF
Brass Work
USED BY
MARINE ENGINEERS.
WHITEFIELD BRASS WORKS,
GOVAN, GLASGOW. 6733

7974
CHAMBERS, SCOTT & CO., Ltd.
BUILDERS OF
CRANES, WINCHES,
HOISTING & HAULING MACHINERY,
MOTHERWELL.



ALFRED
BEEBEE,
WEDNESBURY.

3696

Cushman's Booklet
of Lovejoy Chucks
Now Being Issued
Copies Gladly Mailed on Request
THE CUSHMAN CHUCK CO. HARTFORD, CONN. U.S.A.

Stern Wheel Steamers. Bucket and Suction Dredgers
Tin Dredgers. of all Sizes.
Gold Dredgers.

LOBNITZ & CO., LTD.
ENGINEERS & SHIPBUILDERS,
RENFREW, SCOTLAND.

7744

Telegrams:
"LOBNITZ,
RENFREW."

Sole Makers
of Patent Rockcutter.
For rock excavation under water without explosives.

PROPELLERS

EITHER SOLID OR . .
WITH LOOSE BLADES.

Any Size made at the Shortest Notice.

4318

HIGHEST EFFICIENCY.
LOWEST CONSUMPTION.

FRIEDENTHALS LTD., RIVER ENGINE WORKS, PRESTON.

PIPE LINES

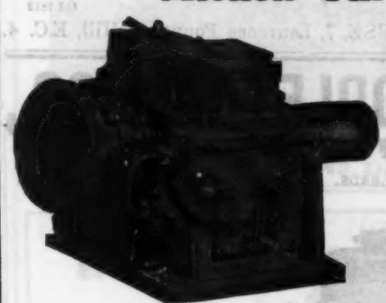
8117

WATER, STEAM, OIL, AIR, GAS, HYDRAULIC.

CONTRACTS COMPLETED THROUGHOUT UNITED KINGDOM AND ABROAD.

J. W. HOUSTON & CO., PATRICK CROSS, GLASGOW.

Michell Thrust Bearings



The fact that these are being fitted into the largest liners is evidence of their quality. They are also used in turbines, pumps, vertical motors and other machines having strong axial thrust, as they develop far less friction than ordinary thrust bearings, and lubricate perfectly. List on request.

TELEPHONE 93. 6284

BROOM & WADE LTD., HIGH WYCOMBE.

More Than Six Times Its Cost

saved the first year on one

"ELASTIC ROTARY"
(Trade Mark)
Blow Riveting Machine

is the report of one manufacturer.

Better investigate your riveting costs and see if you can't save as much. 7413

May we send you catalogue with full details?

THE F. B. Shuster Co., New Haven, Conn., U.S.A.
Formerly John Adt & Son. Established 1866

Also Makers of Wire Straighteners and Cutters.

The New
"KOH-I-NOOR" Valve

EMBODIES NEW FEATURES ENSURING:

1. SAFETY.
2. RELIABILITY.
3. ECONOMY.

Science and art in design and manufacture respectively, coupled with 20 years' of experience in manufacturing valves enable us to satisfy the *most exacting conditions.*

Write for particulars to the Makers:

London Office:
5, SOUTHWARK STREET,
LONDON, S.E.1.

KENNEDY'S (CARNTYNE) Ltd.,
SHETTLESTON, GLASGOW.

7703

MICA

F. WIGGINS & SONS.
Telephone: Avenue 1240.
FOR INSULATION, FURNACE DOORS, SIGHT-HOLES, &c.
Largest Stock in the World. Cd 9634
102, 103, & 104, Minories, LONDON.

Pneumercator Draught Indicator

Indicates fore and aft draught, Registers mean draught, shows tons displaced—registers in all weathers quickly and accurately.

Pneumercator Tank Gauge

RBB 6682

Indicates instantaneously the amount, gallons, or tons of any liquid or semi-liquid in any vat, tank or reservoir. Fitted with an alarm—it warns of any deviation from pre-determined level. Send for Booklets.

KELVIN, BOTTOMLEY & BAIRD, Ltd., Cambridge St. Glasgow.

Thomas Turton & Sons, LIMITED.

MANUFACTURERS OF

ENGINE, CARRIAGE, AND WAGON SPRINGS,

Cast Steel Files,

ENGINEERS' TOOLS, HAMMERS, EDGE TOOLS, STEEL FORGINGS SPRING STEEL.

Tool Steel.

SHEAF WORKS, SHEFFIELD.

Cd 7813

London Office: NORFOLK HOUSE, 7, Laurence Pountney Hill, E.C. 4.

ROBERT MIDDLETON & CO.,

SHEEPSCAR FOUNDRY, LEEDS.

Tel. 364. Tel. Add.: "HYDRAULIC," LEEDS. Codes used: A B C, 5th Ed. Liebers.

OVOID BRIQUETTE MACHINE. 8008

MODERN BRIQUETTE MACHINERY

FOR COAL, CHARCOAL, COKE, AND ORES.

VERTICAL & HORIZONTAL DOUBLE PRESSURE MACHINES.

OVOID MACHINES.

Catalogues and Illustrations free.

Shortage of Coal and Labour.

Mechanical Stokers are now a necessity.

"One of the best machines is the TRIUMPH."

TRIUMPH STOKER, LTD.,
KIRKSTALL ROAD, LEEDS. 7955

JOHN RUSSELL & CO., LD.

WALSALL.

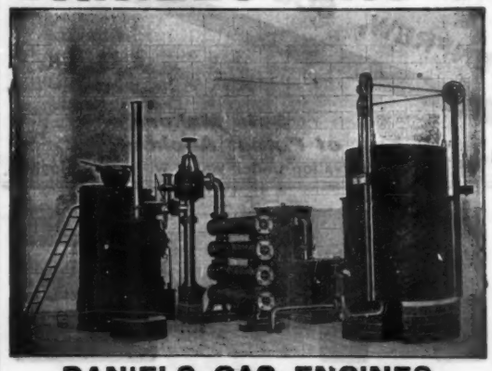
LAPWELDED & SOLID-DRAWN

TRADE MARK. **TUBES** 7887 TRADE MARK.

FOR LOCOMOTIVE AND OTHER BOILERS AND GENERAL ENGINEERING PURPOSES

ON ADMIRALTY LIST OF CONTRACTORS.

DANIELS GAS PLANTS.



SUCTION GAS PLANT

For Anthracite COKE and CHARCOAL FUEL.

Will work perfectly from FULL LOAD to NO LOAD or drive TWO or more ENGINES from One Suction Plant.

10 TO 20 HP. FOR ONE PENNY PER HOUR.

Pressure and Suction Types.

Comp ete Pumping Installations.

DANIELS GAS ENGINES.
DANIELS HIGH-SPEED PUMPS.

T. H. & J. DANIELS, Ld., Stroud, Eng.

Get a Film!

A SOFT, smooth, slippery film of Foliac Graphite to fill in and smooth over the microscopic irregularities that exist in the finest bearing surfaces and are the cause of friction. Such a film is set up and maintained by—

Foliac GRAPHITE 7137

Cup Grease

You will appreciate an economy effected by your first supply, as also the smooth, cool and eventless running of your machinery.

Write us for free sample and example of a Film of Graphite.

GRAPHITE PRODUCTS Ltd.,
218-220, QUEEN'S RD., BATTERSEA, LONDON, S.W. 8.

Heywood & Bridge's

FRICTION CLUTCHES

IMPROVED PATENTS

What the User says.

4— "Working admirably...have ordered this type alone for extensions."

Here the Heywood & Bridge Clutch was used to the exclusion of all others. It is a common state of affairs once our clutches have been installed. No matter how difficult the drive, they may be relied upon to do their work *admirably*. Light or heavy loads can be started and stopped without shock or jar; wear and tear on belts and machinery is reduced to a minimum, and satisfactory service and safety are assured.

Catalogue (C 49) illustrates scores of representative drives to which this well-known clutch has been successfully applied. Post free. 8053

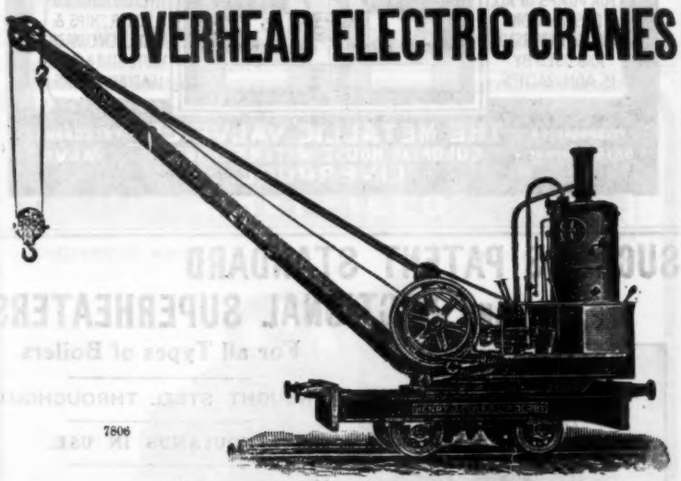
DAVID BRIDGE & Co. Ltd.

Castleton, Manchester.

London Offices: 36, Queen Victoria St. E.C.

STEAM CRANES,

OVERHEAD ELECTRIC CRANES



7806

Telephone No.: 1266 DERBY. Telegrams: "COLES, DERBY."

HENRY J. COLES, Ld., London Crane Works, Derby

THE STANDARD ENGINEERING Co LTD LEICESTER

MAKERS OF 7588

SHEET STEEL PIPING,

WELDED, RIVETTED OR SEAMED.

GENERAL LIGHT SHEET IRON WORK.

JOHNSTON LINE

Liverpool, Swansea and Antwerp

TO

Mediterranean,

Black Sea and Danube.

DIRECT PORTS:

Piræus, Volo, Salonica, Bourgas, Varna, Constantza, Sulina, Tulcea, Galatz, Braila.

Also calling at

Medua, Cattaro, Durazzo, Prevesa, Calamata, Canea, Candia, Cavalla, Dedeagatch, Samsoun, and Trebizonde.

(As Inducement Offers.)

Enquiries are invited, and shippers are requested to communicate with the undersigned for full particulars as to Rates, Sailings, and ALL other information.

JOHNSTON LINE LIMITED,
6, Billiter Street, London; 9, Mount Street, Manchester;
J. & A. ROXBURGH, Glasgow,
M. LANGLANDS & SONS, Dundee,
AND 7597

FURNESS, WITHY & CO., LIMITED,

Royal Liver Building, LIVERPOOL.

Also at NEWCASTLE-ON-TYNE, CARDIFF, LEITH and MIDDLESBROUGH.

MERRYWEATHERS' PATENT

Water-Tube "Safety" BOILERS.

5 HP. TO 250 HP.

This Photograph, taken "Up Country," speaks for the Lightness and Portability of Merryweather Boilers.

For COAL, WOOD, or OIL FUEL

The Ideal Boiler for EMERGENCIES and for all cases where Lightness, Portability, and Small Bulk are essential.

A large user of Merryweather Boilers in the East says they are easily worked and kept in order by Native labour. The Boilers were used under very severe conditions, on bad water and for long periods.

ESTIMATES SUBMITTED. 7555

MERRYWEATHER & SONS, Ltd., Greenwich, S.E. 10, London.

To His Majesty King George V.

By Appointment.

WAYGOOD-OTIS LIFTS

7564

Waygood-Otis Ltd. (Estab. 1852), London, S.E. Telephone 5000 Day (Night and Day).

S. SMITH & SONS, LTD.

NEWEST TYPE OF CHRONOGRAPH WATCH.

THE "CHRONOMNIA" OF RECKONALL.

RECORDS IN HOURS, MINUTES, SECONDS, AND FIFTH-SECONDS.

FOR DEFINING AND RECORDING TIME WITHOUT LIMIT.

CAN BE APPLIED TO EVERY CONCEIVABLE OBSERVATION OF TIME.

MAKERS OF CHRONOGRAPHS AND CHRONOGRAPH WATCHES TO THE WAR DEPT., ADMIRALTY, etc., etc.

WRITE FOR SUPPLEMENTAL LIST OF OUR LATEST PRODUCTIONS.

SILVER CASES, £12:12:0

Chronographs FROM £2:0:0 UPWARDS.

WRITE FOR FURTHER PARTICULARS OF THIS INSTRUMENT TO 7833

OUR ONLY ADDRESS:

6, GRAND HOTEL BUILDINGS, TRAFALGAR SQUARE, LONDON, W.

CRADOCK'S ROPES

ARE MANUFACTURED ONLY FROM THE HIGHEST CLASS BASE OF

ENGLISH HAEMATITE AND SWEDISH CHARCOAL PIG IRON } Converted into STEEL at CRADOCK'S OWN WORKS.

And SUPPLIED IN THE FOLLOWING GRADES:— 3822

Guaranteed Swedish Base—Special Acid.
Guaranteed Special Acid, Guaranteed Acid.

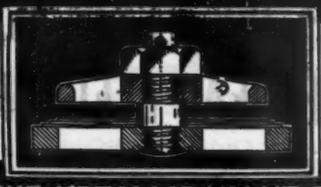
CRADOCKS ALSO SUPPLY ROPES MADE FROM

Guaranteed English Basic (In one Grade only, viz., 70/90 tons sq. in.) } This Material is Purchased in the Billet and subsequently manufactured at their Works.

GEORGE CRADOCK & CO., LTD., WAKEFIELD.

KINGHORN'S PATENT VALVES

THE BEST VALVE FOR PUMPS OF ALL DESCRIPTIONS ADOPTED UNIVERSALLY AND USED BY 15 ADMIRALTIES.



FITTED TO H.M.S. DREADNOUGHT & SISTER SHIPS & TO THE NEW CUNARD WHITE STAR & OTHER LEADING LINERS.

TELEPHONE :- 5818 CENTRAL

THE METALLIC VALVE Co COLONIAL HOUSE, WATER STREET, LIVERPOOL.

TELEGRAMS: "VALVE"

6516

BLAIR, CAMPBELL & McLEAN, LIMITED

GOVAN, GLASGOW.

ESTABLISHED 1838.

Sugar-making, Refining, Distillery, Brewery & Chemical Plant.

Wood Distillation Plants,

with recovery of all By-products, including Acetone, Formaldehyde, Ether, Oxalic Acid, &c.

Stills, Evaporators, &c., of Iron, Copper, Gunmetal or Silver.

Rectifying Stills of Continuous and Discontinuous Type for:

Acetone	Acetic Acid	Ammonia	Alcohol
Turpentine	Carbolic Acid	Wood Alcohol	Wood Oils
Pyridene	Ether	Naphtha	Solvent Oils, &c.

SPECIAL APPARATUS FOR

Pure Benzol, Toluol, Xylol, Naphthals, Naphthalene, Carbolic Acid Crystals. Complete Installations for making 40 per cent. and pure Anthacene, Pyridene, Anilin and Alizarin Dyes, Salicylic Acid, Aqua Ammonia, Acid Tar Regenerating Plant, &c.

SOLE MAKERS OF

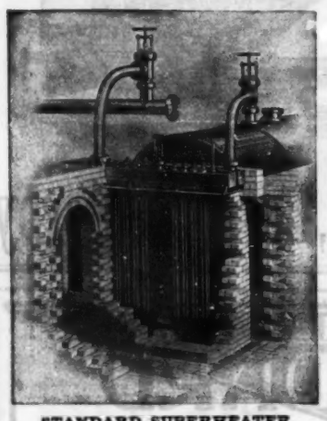
"MULTIPLEX" FILM EVAPORATORS.

"Imperial" Patent Drying Machines. 6553

SPECIAL PLANT: Autoclaves, Vacuum Pans and Dryers, Rendering Plant, Condensers, Caustic Soda Solidifiers, Gas and Vapour Scrubbers, Extraction Apparatus, &c.

SUGDEN'S PATENT STANDARD AND SECTIONAL SUPERHEATERS

For all Types of Boilers.



STANDARD SUPERHEATER as applied to a Lancashire Boiler.

WROUGHT STEEL THROUGHOUT.

THOUSANDS IN USE.

Main advantages:—
SIMPLICITY OF DESIGN
and
READY ACCESSIBILITY to all parts.

Write for Illustrated Circular:

T. SUGDEN, Ltd.
180, FLEET STREET,
LONDON, E.C.

Telegrams: TUBULARITY, LONDON.
Telephone: No. 186 Holborn. 779

Representatives in all principal Towns.

GRAFTON & CO.

CONTRACTORS TO H.M. GOVERNMENT,
CYCLOPS WORKS,
BEDFORD.

Telegrams—Grafton, Bedford.

Illustrated Descriptive Price List free on application.

SILVER MEDAL, Inventions Exhibition, London, 1885. GOLD MEDAL, Paris, 1900.
GRAND PRIX and GOLD MEDAL, Franco-British Exhibition, London, 1908.
GRAND PRIX, Buenos Aires Exhibition, 1910.

BROWNING LOCOMOTIVE CRANES

The All-around Champion

BROWNING

Buckets for all purposes. Send for Crane and Bucket catalogs.

The Browning Co.
Cleveland, Ohio, U. S. A.
Cable address: Brownengin.

AUTO. TOOTH-ROUNDING ATTACHMENT

For Use on Milling Machines.

Suitable for Gears from 2 in. to 9½ in. pitch diameter, and 4 to 10 diametral pitch.

Will round or chamfer 6 teeth per minute.

The attachment is complete with worm (of required pitch), one cam for semi-circular motion, cutter and countershaft. Worms of other pitches can be furnished. Three cams are necessary for the range of gears from 4 to 10 diametral pitch.

IN STOCK.

SELSON
Engineering Co., Ltd.,
3481
83-85, QUEEN VICTORIA STREET, LONDON, E.C. 4.

LLOYDS BANK LIMITED,

with which is amalgamated

THE CAPITAL & COUNTIES BANK, LTD.

7618

HEAD OFFICE: 71, LOMBARD ST., E.C. 3.

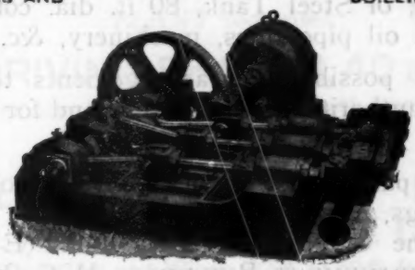
COLONIAL & FOREIGN DEPARTMENTS: 17, CORNHILL, E.C. 3,
and at
BIRMINGHAM, BRADFORD, LIVERPOOL, MANCHESTER, NEWCASTLE-ON-TYNE.

Foreign Bills and Cheques are collected, and approved Bills purchased. Letters of Credit and Circular Notes are issued, and Foreign Currency Drafts, Telegraphic Transfers, and Letter Payments, available in all parts of the world, can be obtained from the principal Branches.

The Agency of Colonial and Foreign Banks is undertaken.

DAVY BROS. LTD
SHEFFIELD.

ENGINEERS AND BOILERMAKERS.



8011

HORIZONTAL THREE-THROW PUMPS FOR HYDRAULIC INSTALLATIONS.

HIGH-CLASS CONSTRUCTION FOR HEAVY DUTY.

FORGED STEEL PUMP AND VALVE BOXES. IMPROVED CAGE-SEAT VALVES.

ENCLOSED CUT DOUBLE-HELICAL GEAR.

HIGH-SPEED FORGING PRESSES.

ROLLING MILLS AND STEEL WORKS MACHINERY.

MAXWELL & FAGE

(Successors to BRUCE & STILL, Limited.)

49, SEFTON STREET, LIVERPOOL.

CONSTRUCTIONAL ENGINEERS and CONTRACTORS.

FOR STEEL BUILDINGS BRIDGES GIRDERS AND ALL DESCRIPTIONS OF STRUCTURAL WORK.

TIMBER BUILDINGS DESIGNED FOR USE AT HOME AND ABROAD.

London Representative: B. J. ALLISON, A.M.I.M.E., 53, New Broad St., E.C. Tel. 1127 L.W.

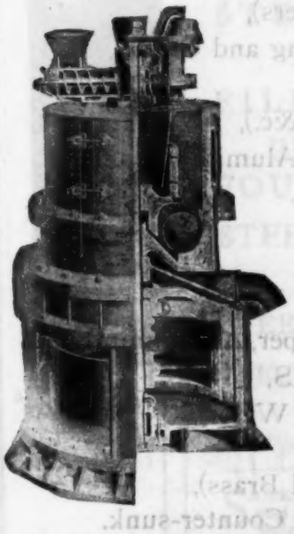
Building for Wagon Repairs. Erected by us.

Catalogues, Designs and Estimates free on application.

Telephone: No. 1317 ROYAL. 7869 Telegrams: "GALVANIZER, LIVERPOOL."

Pulverized Coal Equipment

AMONG some of the plants using our Pulverized Coal Equipment for heating Industrial Furnaces and Steam Boilers are the following.



AMERICAN IRON & STEEL CO.
Open Hearth, Puddling and Heating Furnace.
AMERICAN LOCOMOTIVE WORKS.
Steam Boilers.
AMERICAN SMELT. & REFINING CO.
Reverberatory Furnaces.
AMERICAN STEEL & WIRE CO.
Open Hearth Furnaces.
AMERICAN STEEL & WIRE CO.
Heating Furnaces.
ATCHISON, TOPEKA & SANTA FE R. R.
Locomotives.
ATLANTIC STEEL COMPANY.
Open Hearth Furnaces.
ASH GROVE LIME & PORTLAND CEMENT CO.
Steam Boilers.
BETHLEHEM STEEL CO.
Open Hearth Furnaces.
CHOCTAW PORTLAND CEMENT CO.
Steam Boilers.
INLAND STEEL CO., Heating Furnaces.
LACKAWANNA STEEL CO. Calcining and also Flue Dust Nodulizing Kilns.
M.K. & T. RAILROAD, Steam Boilers.
MILWAUKEE ELECTRIC LIGHT & POWER CO.
Steam Boilers.
NICHOLS COPPER COMPANY, Smelter.
PACIFIC COAST COAL CO., Steam Boilers.
PITTSBURG MALLEABLE IRON CO.
Malleable Furnaces.
SIZER FORGE COMPANY.
Heating and Forging Furnaces and Steam Boilers.
SCRANTON BOLT & NUT CO.
Heating and Puddling Furnaces.
SPANISH-AMERICAN IRON CO. 8122
Ore Roasting and Nodulizing Kilns.
STONE & WEBSTER CO. Steam Boilers.
UNION CARBIDE COMPANY, Lime Kilns.
UNITED VERDE EXT. MINING CO.
Reverberatory Furnaces and Steam Boilers.

Practically all the Cement Plants in the United States and Canada have installations of Fuller Mills.

Some of the above plants are using Pulverized Coal containing from 10% to 17% of ash for heating their metallurgical furnaces.

Fuller Mills are to-day pulverizing over 25,000 tons of coal per day for heating various types of Furnaces.

The satisfactory performance of our pulverized Coal Equipment warrants your investigation. We manufacture Coal Crushers, Dryers, Fuller-Lehigh Pulverizer Mills, and Pulverized Coal Feeders. All this equipment is described in our Catalogue No. 71, which we will be pleased to send you.

FULLER-LEHIGH COMPANY,

Main Office and Works - - FULLERTON, Pa., U.S.A.

BRANCH OFFICES:—NEW YORK, N.Y., U.S.A., 50, Church Street; CHICAGO, ILL., U.S.A., McCormick Buildings. PARSONS, KANSAS, U.S.A. First National Bank Building.

Special Representatives in the Iron, Steel and Copper Industries for the British Isles: WELLMAN, SEAVER & HEAD, Ltd., LONDON.

LONDON OFFICE:—25, Victoria Street, Westminster, S.W. 1.

Telephone: 4280 Victoria. European Manager: L. C. HARVEY. Telegrams: Pusiecue, 'Phone, London.

G. R.

By Direction of the Disposal Board,

Aircraft Disposal Department,

MINISTRY OF MUNITIONS.

FOR SALE BY TENDER

BOLTS, NUTS, &c.

BOLTS (Hexagon, Bright Steel),
BOLTS (Coachbuilders),
NUTS (Slotted, Wing and Castle),
STUDS,
PINS (Split, Taper, &c.),
WASHERS (Steel, Aluminium, and Duralumin),
HOSE CLIPS,
NIPPLES,
UNIONS,
RIVETS (Steel, Copper, Aluminium),
PETROL FILTERS,
COCKS (Oil, Petrol, Water),
GAUGES (Petrol),
SCREWS (Steel and Brass),
Cheese-head and Counter-sunk.

Large Quantities of the above are available in ALL SIZES.

Enquiries are invited, and Tender Forms and all particulars may be obtained on application to THE CONTROLLER, Aircraft Disposal Department, Welcome Club, Earl's Court.

Telephone—HAMMERSMITH 2300.
Telegrams—"CLEARHOUSE, AEROSUPPLY, LONDON."
Nearest Station—WEST KENSINGTON.

NOTE.—For full particulars of other Government property for Sale, see *SURPLUS*, price 3d., at all bookstalls; or by quarterly subscription of 2/-, post free, payable in advance, to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W.1. C 363

G. R.

MINISTRY OF MUNITIONS.

By Direction of the Disposal Board
(Plant and Machinery Section).

FOR SALE, BY PUBLIC TENDER,

OIL FUEL INSTALLATIONS

Lying at King George Dock, Saltend, Hull.

Consisting of STEEL TANK 80 ft. dia. by 30 ft. deep. Capacity 3760 tons, 40 cu. ft. per ton. Siemens-Martin steel equal to Lloyds' Tests. Water and oil pipe lines. Pump House and everything complete, including Water Storage Tank 29 ft. by 25 ft. by 9 ft. Ref. G. 1419.

A similar Installation to above lying at Hendon Road Reservation, adjacent to Alexander Dock, Hull. Consisting of Steel Tank, 80 ft. dia. complete with water and oil pipe lines, machinery, &c.

It is possible for arrangements to be made with the authorities owning the land for the renting of same. Ref. G. 1331.

Full particulars of the above, also inspection of drawings, can be seen at this Office, on application to the CONTROLLER, D.B.1.(E), CHARING CROSS EMBANKMENT BUILDINGS, W.C. 2.

Tenders for installation at KING GEORGE DOCK, Saltend, must be received not later than 10 a.m. JANUARY 8TH, 1920 (Revised date), and Tender for installation, situate near Alexandra Dock, must be received at 10 a.m., on 15TH JANUARY, 1920 (Revised date).

GASHOLDERS AND TANKS.

SINGLE LIFT HOLDER AND TANK complete, 20,000 cu. ft. capacity. Lying at Kingsnorth, Chatham.

DOUBLE LIFT HOLDER AND TANK complete, 40,000 cu. ft. capacity. Lying at the works of Messrs. Newton, Chambers & Co., Sheffield.

Full particulars and permits to view can be had on application to the CONTROLLER, D.B.1.(E.), CHARING CROSS EMBANKMENT BUILDINGS, W.C 2.

Tenders for above close JANUARY 7TH, 1920.

NOTE.—For particulars of other Government Property for sale, see "SURPLUS," Price 3d., at all Bookstalls; or by Quarterly Subscriptions of 2s. post free, payable in advance to the DIRECTOR OF PUBLICITY, Ministry of Munitions, Whitehall Place, London, S.W 1. C 190

G. R.

MINISTRY OF MUNITIONS

By Direction of the Disposal Board (Plant and Machinery Section).

FOR SALE BY PUBLIC TENDER.

PILE DRIVING PLANT

LYING AT

CHEPSTOW, PORTHBURY, BEACHLEY.

PLANT comprises:

PILE DRIVING FRAMES, 40 and 50 ft.
with different size Hammers, complete with Winch and Boiler.

DOUBLE AND SINGLE LEADER STEEL AND TIMBER PILE DRIVERS
complete with Boiler and Winch, 40 ft. to 50 ft. frame, Hammers 30 and 40 cwt.

500 12 in. SIMPLEX PILES, 16 ft. long.

Quantity of PILES, 38, 35, 30, 26 ft. long.

CLUTCHES, 12 ft. 6 in., 30 ft., 40 ft.

Large Quantity of JOISTS.

Fuller particulars, together with Tender Forms and Permits to View, can be obtained on application to
The CONTROLLER, D.B.I. (E),
Charing Cross Embankment Buildings, W.C. 2.

NOTE.—For particulars of other Government Property for Sale, see "SURPLUS," price 3d., at all Bookstalls, or by quarterly subscriptions of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1.

C 337

Sankey

PLATE & SHEET METAL PRESSINGS & STAMPINGS

AEROPLANE PARTS

HEAVY AND LIGHT STEEL STAMPINGS

HYDRAULIC STEEL PRESSINGS

STEEL FILING CABINETS

PRESSED STEEL FOUNDRY LADLES

STEEL STORAGE BINS

SANKEY STEEL MOTOR WHEELS

SPECIAL STEEL SHEETS

For Engineering, Electrical and Hardware Trades.
(HYDRAULICALLY FLATTENED).

SANKEY Plate and Sheet Metal Pressings and Stampings are made any size or weight, rough or machined, single piece or combination pressed and welded by Oxy-acetylene and other processes. Our equipment includes 750 ton Hydraulic and other Presses and Stamps.

SEND DETAILS OF YOUR REQUIREMENTS AND WE WILL QUOTE YOU.

Joseph Sankey & Sons, Ltd.,

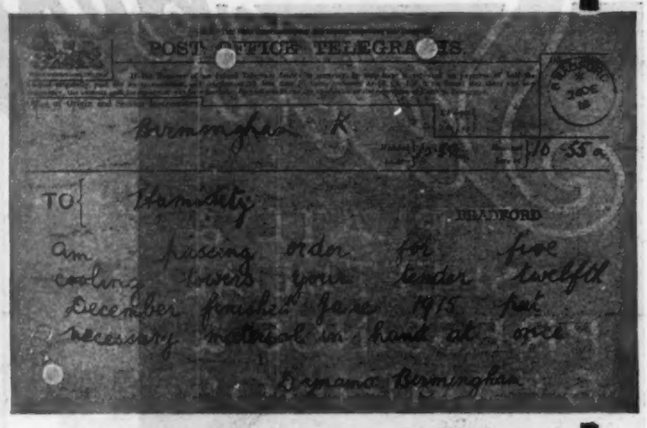
Registered Office:
BILSTON. 7604

'Phone: Bilston 115 (5 lines).

WORKS:

Bilston:	Ettingshall:	Wellington:
Albert Street Works; Bankfield Works.	*Manor Street Iron Works.*	*(Shropshire) Hadley Castle Works.*

THE ORDER TO START DECEMBER 24th, 1914—


POST OFFICE TELEGRAPHS.

Birmingham K

TO Humidity BRADFORD

Am passing order for five cooling towers your tender twelfth December finished June 1915 put necessary material in hand at once

Dynamo Birmingham

ALL BRITISH.

THE "BRADFORD" COOLERS.

THE DAVENPORT ENGINEERING CO., Ltd.

HEAD OFFICES:—
HARRIS STREET, BRADFORD.

TELEPHONES— 6127
3450, 3551, 3552, 3553 Bradford.

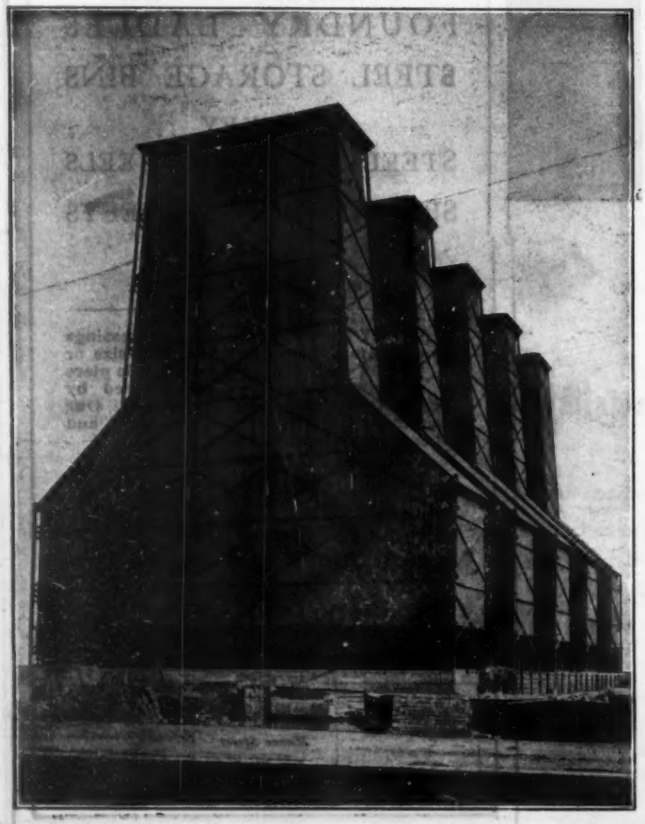
TELEGRAMS—
"Humidity, Bradford."

AND AT HULL, FLEETWOOD, LONDON, LIVERPOOL

G.E.C. 15

7827

FINISHED TO DATE.



PAISLEYS
BOILER SUITS

are celebrated throughout Great Britain and known to Engineers over the whole world The figure represents a SPECIAL SUIT much in favour with Boiler Inspectors, and supplied by us to many of the leading Insurance Companies in Scotland and England.

INSPECTOR'S SUIT.
Instructions for Self-measurement.

	ins.
Length from centre of back to wrist (arm slightly bent)	
Length of arm (inside)	
Length from fork to bottom of leg (inside measurement)	
Length from armpit to bottom of trousers	
Width round chest	
Width round waist	
Width round seat	
Width round thigh	
Width round bottom of leg...	

Please give height—
.....ft. .....ins.

INSPECTORS BOILER SUITS, to measure in Drabette and Drab Jean. Double Knees and Elbows ...	25/- and 27/6 per suit.
Ordinary Stock Sizes, Ready made ...	13/6 per suit.
Double Knees and Elbows	21/- per suit.
ORDINARY BOILER SUITS, buttoned straight down front, in Blue Dungaree, and Brown Denim, Detachable Buttons ...	12/6, 14/6, 15/6 and 17/6 per suit.
BROWN GOVERNMENT JEAN BOILER SUITS	16/6 per suit.
WHITE BOILER SUITS...	15/6 per suit.
KHAKI BOILER SUITS...	14/6 per suit.
BOILER SUITS to measure	2/6 extra.
GOVERNMENT JEAN JACKET AND BIB TROUSERS	17/6 per suit.
BROWN AMERICAN DRILL JACKETS OR TROUSERS	Trousers 7/6 and Jacket 9/-
BROWN AMERICAN DRILL OVERALL TROUSERS (American Shape)	10/6 per pair.
BLUE DUNGAREE JACKETS	6/9 and 8/- each
Do. do. BIB TROUSERS ...	7/9 and 9/6 per pair.
KHAKI LONG COATS...	10/6 and 13/6 each.
KHAKI ST. CRISPIN COATS	11/6, 15/6, 18/6 and 22/6 each.
BLUE ST. CRISPIN COATS ...	11/6, 15/6 and 17/6 each.
KHAKI COATS, three-quarter length,	9/11 and 13/6 each.

Postage—Purchases over 10/- Carriage Paid in the U.K.

Illustrated Catalogue Free by Post. 6735

PAISLEYS Ltd.,
72/96, Jamaica Street, GLASGOW.

Power Transmission Points

No. 2.—Belt Slip.

Slip must not be confused with Creep; the latter is the action of the belt adjusting itself to the tight and slack side of the drive during its circuit of the pulleys. The former is due to many reasons which can be overcome, *e.g.*, the belt may be too slack; it may be under its work, the centres of the driving and driven pulleys may be extremely short, or the atmosphere may be unsuitable to the type of belt used. With creep there is an irreducible loss of speed (or power) which is generally acceded to be 2%. If you were to instal

Walker's Belting

7885

you would absolutely ensure yourself against any loss beyond that due to creep. By virtue of the method of its production our belting has a natural resiliency and has also that clinging factor which increases the arc of contact—therefore it delivers the power at a maximum.

With regard to the matter of Belt Slip—if you have any difficulties let us know. We have had 95 years' experience in the manufacture and application of Belting and we shall be glad to advise you.

Wm. Walker & Sons, Ltd.,
Bolton, England.

F3

THE WORLD'S BEST ELECTRODES

AMORPHOUS CARBON ELECTRODES

for all Electro Chemical and Metallurgical purposes.

8089

THE ELECTRODE CO OF SHEFFIELD LTD.

Offices & Works · WINCOBANK · SHEFFIELD.

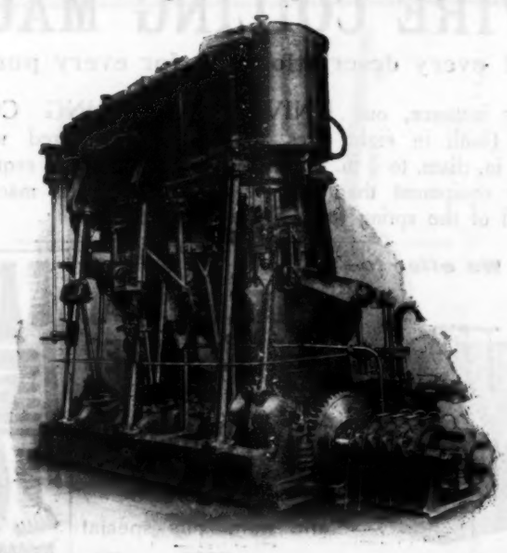
Telegrams: ELECTRODES ROTHERHAM. Telephone: 783 ROTHERHAM.

CAMPBELL & CALDERWOOD,

Engineers and Shipbuilders,

Soho Works, PAISLEY, SCOTLAND,

CONTRACT for Vessels Complete for Shipment in Pieces or in Sections



SHIPMENT WORK A SPECIALITY—

All Types SCREW ENGINES, SIDE AND STERN WHEEL PADDLE ENGINES
Designed for Lightest Draft and Speed.
Smallest Size ENGINES up to 1500 HP.
Independent STEAM-DRIVEN CONDENSING PLANT.
Independent STEAM-DRIVEN CENTRIFUGAL PUMPS.

CATALOGUES ON APPLICATION.

Telegraphic Address: "Soho," Paisley. 7705
Codes: Marconi International; Engineering; A B C (5th Edition).

Drummond Lathes

D 8—10.

Inspector's Test Card.

Type of Lathe 7" (r) Motor Drive No. 229

Date Inspected 10 11 1919 By J. Taylor Rose

Test taken when machine was properly levelled up.

Description of Test.	Maximum Error Allowed.	Error Found.
Mandrel lineable with bed	.001 in 3"	.0008
Headstock lineable with Tailstock	.002 High nil Low .001 Sideways	.0008 .0005
Surfacing square with bed	.002 in 1"	.0006
Face plate runs true	.002	.0008
Live Centre runs true	.001	.0005
Saddle works freely along bed		OK
Cross slide runs freely		OK
Mandrel works free without shake		OK
Back-gear runs true and engages properly		OK
Change-wheels fit studs, run free and in line		OK
Fly-wheel properly in line with cone pulley		OK
Treadle runs easy		OK
Spanners fit nuts		OK

Every Drummond Lathe

is subjected to an inspection and test for accuracy, the results of which are entered on a card as above.

WE will supply any customer with a duplicate "Inspector's Test Card," and guarantee the machine to be within the limits of accuracy specified thereon.

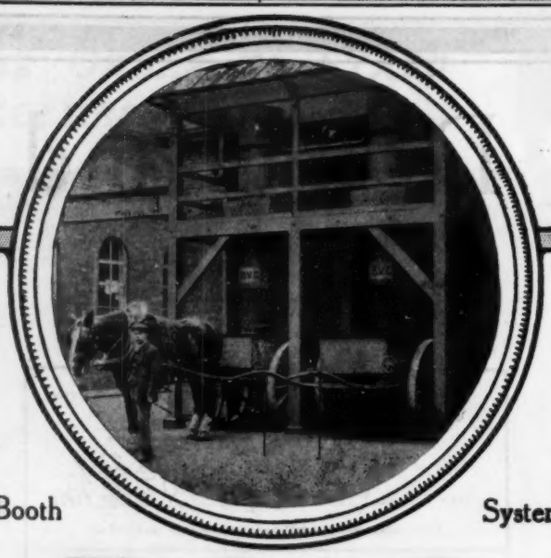
THE Illustration is a reproduction of an actual Test Card, and is an average result.

For full particulars write

Drummond Bros. Ltd.

Engle Works,
GUILDFORD.

7367



Booth System

B.V.C

7835

VACUUM DUST-REMOVAL PLANT

SAVES LABOUR, TIME AND EXPENSE
in removing dust from

BOILER FLUES, ECONOMISERS, FACTORIES, CHEMICAL WORKS, &c., &c.

Vacuum Pumps, Turbo-Exhauster.

THE BRITISH VACUUM CLEANER CO., LTD.,
Dept. S/20. PARSON'S GREEN LANE, S.W.

MEX

Auxiliary Firing
with
MEX FUEL OIL.

SAVING IN COST OF FUEL.

TESTS carried out at a London power station with auxiliary firing at the end of 1915 demonstrated that even a very small percentage of oil has a marked effect on efficiency. Using only 5% of oil to coal on a weight basis, the boiler efficiency was increased 5%. Taking the cost of the oil at 50s. per ton, and coal 20s. 10d. (prices in 1915), a monetary saving of 6% resulted.

Our engineers who have closely studied this aspect of oil firing are at your service for free consultation.

ANGLO-MEXICAN
PETROLEUM CO., LTD.

7832

Fuel Oil (U.K.) Dept.
16, FINSBURY CIRCUS, LONDON, E.C. 2.

On Admiralty, War Office and India Office Lists.

The Metallurgical Co. Ltd.

82, VICTORIA STREET, Westminster, London, S.W.

Works:
Walker Gate, Newcastle-on-Tyne

London Telegrams:
"Llatemiago," Vic., London.
Telephones:
1868 & 1939 Victoria, London.
Works Telegrams:
"Ingots," Newcastle-on-Tyne.
Telephones:
3551 & 3552 Central, Newcastle-on-Tyne.

MAKERS OF
HIGH-CLASS ALLOYS IN INGOTS
TO GOVERNMENT, RAILWAY, OR
ANY OTHER SPECIFICATION.

GUNMETAL & PHOSPHOR BRONZE INGOTS
Guaranteed to Admiralty and War Office Specifications, or any other specified mixture.

MANGANESE BRONZE INGOTS
to War Office and Admiralty Specifications, and special K. V. B. quality, testing 40 tons Tensile, 20 tons Yield and 20–24% Elongation.

SPECIAL BRASS INGOTS
A. B. C. & G. qualities to War Office Specifications.

7332

MANGANESE COPPER, FERRO ZINC, NAVAL BRASS,
Babbitt and White Metal Ingots of every description.

ORDINARY YELLOW BRASS AND GUN METAL INGOTS
for Commercial Work.

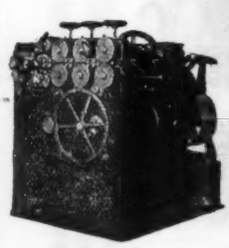
BEST SELECTED COPPER INGOTS, "M.C.L." BRAND.

SPRING COILING
— AND —
WIRE COILING MACH'Y

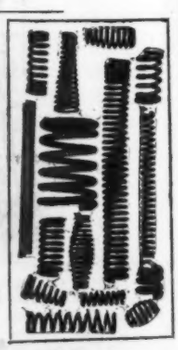
of every description and for every purpose.

For instance, our UNIVERSAL SPRING COILERS (built in eight sizes, to handle oil-tempered wire from ·004 in. diam. to ⅝ in. diam.) will produce, without requiring any other equipment than that furnished with each machine, any or all of the spring forms illustrated herewith.

We offer to— THE
PROFESSIONAL SPRING MAKER
more than
FORTY STANDARD MACHINES
and numerous special ones.



Patented.



7881

SLEEPER & HARTLEY, INC. WORCESTER, Mass., U.S.A.

AGENTS AND REPRESENTATIVES.

U.K.: F. A. PERRY, 68, Queen Victoria Street, London, E.C. 4.
France, Belgium and Switzerland: EDGAR BLOXHAM, 12, Rue du Delta, Paris.
Italy: H. COE & CLERICI, Milan. Australia: EDWIN WOOD PTY. Ltd., Melbourne.
South Africa, New Zealand, India, China, Japan, South and Central America, and Mexico: AMERICAN STEEL EXPORT CO. OF NEW YORK.

Novelty !!!

DISSOLVED ACETYLENE FLARELIGHTS. 7630

NO GENERATOR TO CLEAN
ONE CHARGE EQUIVALENT TO 40 LBS. OF CARBIDE
NO CAPITAL OUTLAY
CYLINDERS LOANED FREE.

106, VICTORIA ST., LONDON, S.W. 1.
Head Office.] Branches: HULL & GLASGOW.

ALLEN-LIVERSIDGE LTD

TERRY TURBINE DRIVE

ADAPTABILITY.

Probably the most difficult element of power plant design is that of allowing for future development and changed conditions. In this respect the design of the Terry is ideal.

The above illustration shows an alternating current turbo-generator set which is giving high efficiency under present conditions but is ready at a moment's notice to carry double its present load.

From partial loads to overloads at proportionately low steam consumption is a Terry feature worthy your immediate investigation.

Write for Bulletin 2515 and find out why this is so.

The Terry Steam Turbine Co.,
Hartford, Conn., U.S.A.

T-617

"METCALF" EMERY WHEEL DRESSER

DRESS A WHEEL WITH A WHEEL. THE SIMPLEST AND MOST EFFECTIVE EMERY WHEEL DRESSER MADE. SAVES TIME AND WHEELS. GET FULL DETAILS FROM:—

JOHN SHAW & SONS (WOLVERHAMPTON), LTD
WOLVERHAMPTON 7567

We invite your enquiries for any class of Machine or Small Tools.

MONEL METAL

Non-corrodible
Strong as Steel
Tough, Ductile

For Superheated Steam Fittings, High Temperature & Caustic Alkaline Conditions

Rods - - Sheets
Bars - Forgings
Castings - etc.

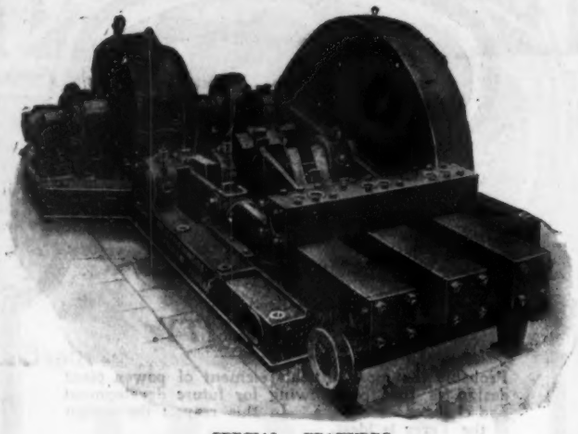
Pamphlet on its Properties and Uses on Application.

7889

G. & J. WEIR, Ltd.,
MONEL DEPT.,
CATHCART GLASGOW

Fullerton

HYDRAULIC PUMP



SPECIAL FEATURES
COMPACTNESS
and
ACCESSIBILITY

6802

FULL PARTICULARS ON APPLICATION.

Fullerton, Hodgart & Barclay, Ltd.
PAISLEY

Codes: ABC 5th Edition. Engineering. Western Union. Marconi Inter.

Telephones: 2163-4 Paisley, P. B. X.
Telegrams: "Vulcan, Paisley."

Telegrams:
PRECOOLER,
SHALFORD.

Water-Cooling Plant
of every description.

Chimney and Open Type Towers.

Spray Coolers.

"Unic" Steam Traps.

Oil Separators.

Dry and Wet Air Filters.

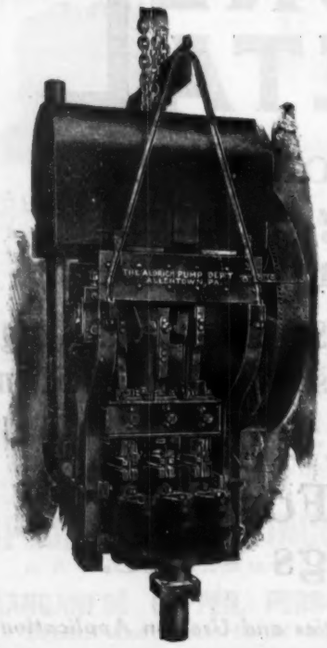
THE PREMIER COOLER & ENGINEERING CO., Ltd.,
Station Works,
SHALFORD, near GUILDFORD, SURREY.

Telephone:
27, SHALFORD.

6606

Aldrich Pumps

FOR VERTICAL SHAFT SINKING.



Cut illustrates a 5½ in. by 7 in. Electric TRIPLEX LINKER rated at 200 U.S.G.P.M. against 350 feet working head. Pump can be raised and lowered at will.

Write for "Pump Data" listing other sizes.

8145

THE ALDRICH PUMP COMPANY,
Allentown, Pa., U.S.A.
British Agents: GILLESPIE & CO., Leadenhall Bldgs., 2, Whittington Avenue.

"COMMER CARS"

For Goods: 2, 3, 3½ and 5 Tonners.
For Passengers: 30 Seaters.

IT is a significant fact that so many of the "Commer Cars" seen on the road bear the names of some of the most important firms in the Country.

COMMERCIAL CARS LTD., LUTON.

Wires:
"KOMERKARS, LUTON."

'Phones:
LUTON 190; HORNSEY 2212.

LONDON REPAIR DEPOT: 113 ...tles Road, Upper Holloway, N. 19.

7501

ENQUIRIES INVITED.

A DISTINCTION WITH A DIFFERENCE

An Oil that is Soluble in Water, but is not a Soluble Oil.

LARDINOL CUTTING OIL.

1. MANUFACTURED ON AN ENTIRELY NEW PROCESS.
2. SUPERIOR TO ORDINARY SOLUBLE OILS.
3. CHEAP AND ECONOMICAL. 7283

Try a sample barrel on approval—it will cost you nothing and may save you much.

PRICE 4/- PER GALLON.

STERNS, Ltd., A.D. 9, Royal London House, Finsbury Square, London, E.C. 2.

Cradley Cross Tube Boilers.

in

STOCK

and

PROGRESS

For LAND and MARINE USE.

7717

CRADLEY BOILER CO., LTD.

CRADLEY HEATH, STAFFS.

Stop Waste!

All the time spent on machining and hand finishing most small parts is time wasted.

50 to 80 per cent. of the cost is money wasted.

Because our perfected method of

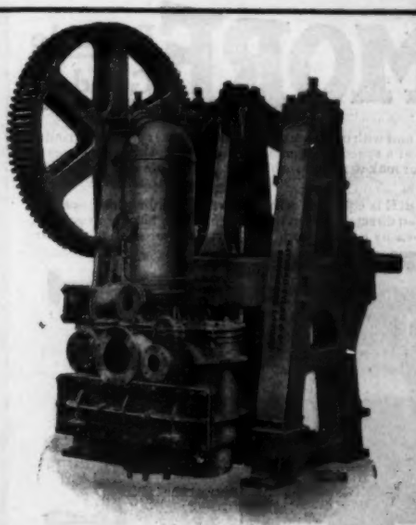
DIE CASTING

will save you all that time and all that money while giving you parts superior in accuracy and of guaranteed quality.

Consult us in confidence. Stop this waste. Increase your output *and profits.*

THE PATENT DIE-CASTING COMPANY, Ltd.,
64, Strode Road, Willesden Green, London, N.W. 10,
Telephone: Willesden 733. 7430

HAYWARD-TYLER & Co Ld
PUMPS & PUMPING MACHINERY.



VERTICAL THREE-THROW PLUNGER PUMP
For Driving by OIL ENGINE.
Duty 42,000 Gallons of Water per hour.

PUMPS SUITABLE FOR ALL PURPOSES

WRITE FOR CATALOGUES.

8064

HEAD OFFICE: Works: LUTON, BEDS.
99, QUEEN VICTORIA STREET, LONDON, E.C.4.

Steel Forgings

Telegrams "Brakes" West Bromwich
Telephone 291 W.B.

Weldless Rings.
Spindles.
Gear Blanks.
Shafts.
Die-finished Work.

Accurate and well finished.
Capacity up to 15 cwt per piece.

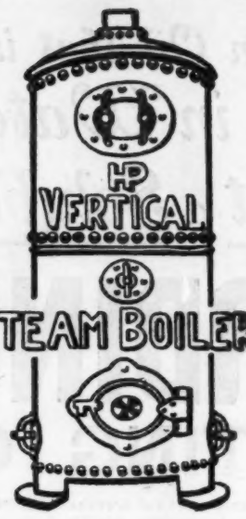
Can be supplied in the rough, rough machined or finish machined.

Electro-Mechanical Brake Co. Ltd.
EMB
West Bromwich Staff.
Established 1908.

Scotland. A.F. Stevenson. 50, Wellington St. Glasgow.
Australia. J.G. Gilbert Lodge 109, Pitt St. Sydney.

T454

HARTLEY & SUGDEN L
HALIFAX, ENG.
ESTABLISHED 1867 LONDON OFFICE, 61 CT PORTLAND ST. W.1.



CONTRACTORS TO THE
ADMIRALTY, WAR OFFICE, COLONIAL OFFICE, ETC

6171

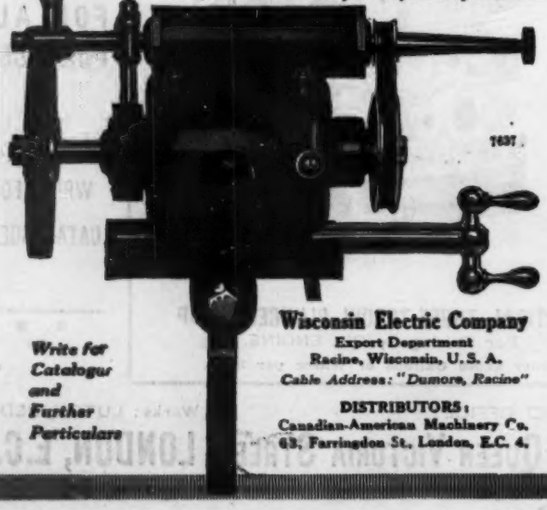
For Grinding Gauges

WOULD you care to save three-quarters of the time it now takes to grind your gauges? You can do so with DUMORE Grinders because they work absolutely accurate and free from taper.

DUMORE Portable Grinders

do more work in less time and with more accuracy than any other portable grinder. This is because they run at a speed high enough to give the wheels the correct cutting speed. The motor makes 10,000 revolutions per minute and the internal attachment 30,000.

The DUMORE is equipped with a universal motor which operates equally well on direct or alternating current. Weighs only 17 pounds, and can be easily carried from one part of your shop to another.



T637.

Write for Catalogue and Further Particulars

Wisconsin Electric Company
Export Department
Racine, Wisconsin, U.S.A.
Cable Address: "Dumore, Racine"

DISTRIBUTORS:
Canadian-American Machinery Co.
63, Farringdon St., London, E.C. 4.

EVERITT & CO.,

40, CHAPEL STREET,
Telegrams: "PERSISTENT."
Telephone: 1134 CENTRAL (3 lines). LIVERPOOL.

FERRO-ALLOYS & METALS.

FERRO-TUNGSTEN, 75/80% and 1% Carbon max. 80/85% and 0·1% Carbon max.
TUNGSTEN METAL POWDER. 98/99%
FERRO-VANADIUM. COBALT METAL.

PHOSPHOR TIN	FERRO-BORON	CADMIUM METAL
PHOSPHOR COPPER	FERRO-URANIUM	ANTIMONY
FERRO-TITANIUM	FERRO-TANTALUM	NICKEL
FERRO-PHOSPHORUS TIN	FERRO-ZIRCONIUM COPPER	ZINC SILICON-COPPER

— SPIEGELEISEN —

FERRO-CHROME. 0·5%, 2%, 4/6%, 6/8%, 8/10% Carbon.
FERRO-SILICON. 9/13%, 25%, 45/50%, 75%, 80/85%, 90%.

ALUMINIUM (Notched Bars, Half-round Sticks, Granules, and Powder)

FERRO-MOLYBDENUM. MAGNESIUM METAL.
SILICON-MANGANESE.
MANGANESE METAL, CHROMIUM METAL. (Carbon free).

MINERALS:
MANGANESE, CHROME, WOLFRAM, SCHEELITE, MOLYBDENITE, FLUORSPAR, MAGNESITE, KIESELGUHR, ASBESTOS, GRAPHITE, ANNEALING IRON ORE, PIG IRON, &c., &c.

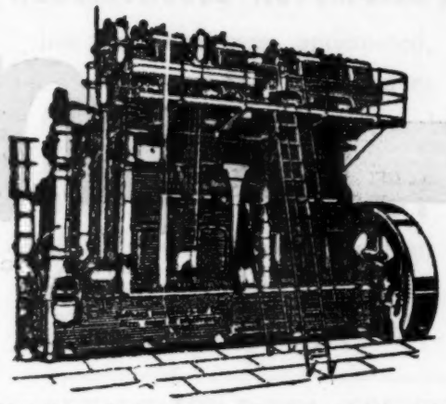
MIRRLEES, BICKERTON & DAY, LTD.,

Hazel Grove, near STOCKPORT.

LONDON Office { 122, Cannon Street, E.C. } Telegraphic Address { "ECONOMY, HAZEL GROVE." }

MAKERS OF

The "MIRRLEES-DIESEL" OIL ENGINE.



500 B.HP. "Mirrlees-Diesel" Engine—Crosshead Type.

THE MOST ECONOMICAL ENGINE MADE

FOR

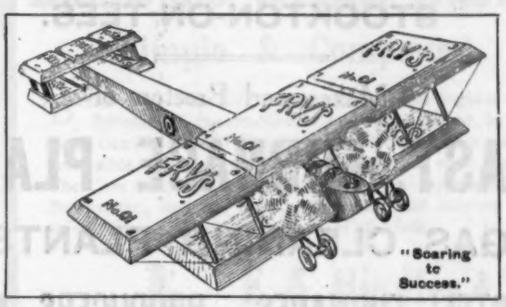
LIGHTING, TRACTION, POWER, PUMPING, PROPULSION, &c.

8007

CHEAP AND SAFE OILS USED AS FUEL.

BEARING FRY'S METALS

Standard Alloys for all purposes. Alloys to Sample or Specification.



"Soaring to Success."

ALLOY No. 01

for

AERO ENGINES

A Tin Alloy combining maximum toughness with great strength.

FRY'S METAL FOUNDRY

25-42, Holland Street, BLACKFRIARS, LONDON, S.E. 1.

Telephone No.: HOP 4720 (3 lines.)
T.A.: Frymetalco, Friars, London.

7856

Also at MANCHESTER
BRISTOL
DUBLIN
GLASGOW

Always Something to Learn!

There is always something to learn about Alloy Steels, their uses, their suitability for specific parts of aeroplanes or motor-cars, and so on. The new edition of the Edgar Allen catalogue

A New Edition

Steels for Motor-Cars AND Aircraft

contains information of interest and value to all engineers and manufacturers.

Write for a Copy, stating name of firm.

Edgar Allen & Co. Limited

Imperial STEEL Works, Sheffield.

PREVENT

Seized Bearings

COOLORICID

IS THE ANTIDOTE FOR HOT BEARINGS. 7969

ALWAYS HAVE A SUPPLY AT HAND.

USED BY H.M. GOVERNMENT.

Packed in 28, 56 and 112 lb. Kegs and 3½ cwt. Barrels.
Price 2s. 6d. per lb., Packages Free, Carriage Paid.

Sole Makers:— **STERNS, LTD.** ROYAL LONDON HOUSE, FINSBURY SQUARE, E.C.

Ashmore, Benson, Pease & Co.,

LIMITED,

STOCKTON-ON-TEES.

Makers and Erectors of

BLAST FURNACE PLANT,

GAS CLEANING PLANTS,

STEEL FURNACES, PRODUCERS, &c.

COAL, COKE & ORE BUNKERS.

Cast Iron and Steel Work
for Coke Ovens and Chemical Plants.

GAS WORKS PLANT OF EVERY DESCRIPTION.

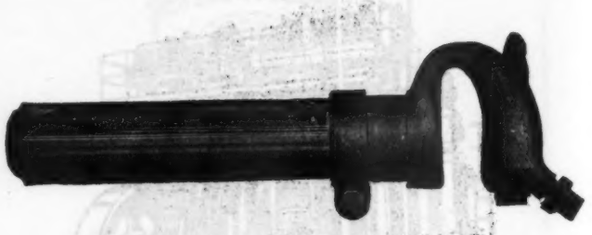
CASTINGS UP TO 20 TONS.

SOLE MAKERS OF

Forter's Patent Reversing Valves

For Steel, Glass and other Furnaces. 7233

The "JOHN BULL" PNEUMATIC TOOLS



PNEUMATIC RIVETERS, CHIPPERS, ETC.

7331

THE HOWARD ESTABLISHED 1904 PNEUMATIC ENGINEERING CO. LTD. EASTBOURNE.

Handling Materials

GRABBING AND HANDLING EQUIPMENT

Thirty complete Steam-Grabs similar to the one above illustrated supplied for use in Iron and Steelworks in the United Kingdom, during two years 1917—1918. 7884

Pamphlet No. 190 will be sent on request.

Priestman Brothers, Ltd.

Holderness Foundry, HULL.

28, VICTORIA STREET, S.W. 1. Telephone No.: VICTORIA 6171.

DROP

YOUR NONSENSE

and don't hesitate when you are wanting Drop Forgings that will satisfy you in every respect, to send your enquiries to

THE SMETHWICK STAMPING CO.,

(Proprietors—Valor Co., Ltd.)

BRIDGE STREET, SMETHWICK,

whose speciality is first-class work and materials. They use high-grade Alloy Steels, and can heat treat them to their being used to the best advantage. They are at your service with up-to-date plant and experience for the production of the best Drop 7651

FORGINGS

To Railway Engineers.

"SAFETY FIRST"

THE WESTINGHOUSE AUTOMATIC BRAKE

has met, and even anticipated, every demand upon its resources for upwards of forty years, and it now contributes to the **SAFETY AND COMFORT** of railwaymen and passengers on the Greatest Number of Railways throughout the World.

LET US HELP YOU SOLVE YOUR TRAFFIC PROBLEMS

THE WESTINGHOUSE BRAKE CO., LTD.,
82, York Road King's Cross, LONDON, N.1.

VERTICAL HIGH SPEED ENCLOSED STEAM ENGINES

Simple & Compound.

Briefly the outstanding advantages of these engines are:—Substantial construction, Governor enclosed in crank case, Convenient Oil Pressure Regulation, Patent Duplex Reversible Strainer, which can be cleaned while running. They are suitable for direct coupling to Dynamos, Fans, Pumps, etc., and are silent, economical and reliable. For ship lighting and industrial works of all kinds.

E. S. Hindley & Sons
11, QUEEN VICTORIA ST. LONDON : : : : : E.C. 4.
Telephone 9804 City (2 Lines). | Telegraph Steampot, Cannon, London.

WORKS BOURTON DORSET.

4 to 300 H.P.

H. & W. TRADE MARK.

HIGH-CLASS MACHINE CUT SPUR-GEARED
LIFTING BLOCKS

The mechanical efficiency of these blocks is very high, and every care is exercised to produce a first-class appliance. Tested to 50 per cent. overload.

HOLT & WILLETTS
LION WORKS
CRADLEY HEATH

WRITE FOR ILLUSTRATED DESCRIPTIVE CATALOGUES

7473

BOILERS

HOLDSWORTH & SONS, LTD.

with which is incorporated The Yorkshire Boiler Co., Ltd.,

CROFT BOILER WORKS,
LEEDS ROAD,
BRADFORD.

Catalogue sent on application.

'Phone 446. Telegrams: "Steam."

London Office: 34, Victoria Street, Westminster.
South Wales: Gordon Chambers, Queen Street, Cardiff.

7481

PRECISION GAUGES LTD.

N.P. L LIMITS.

GAUGES.

JIGS.

FORM TOOLS.

BROACHES.

TRADE MARK.

7498

TELEPHONE— MIDLAND 1016.

TELEGRAMS— "REKRAP, BIRMINGHAM."

WRENTHAM STREET, BIRMINGHAM.

THOMAS PIGGOTT & CO LD.

ATLAS WORKS, SPRING HILL, BIRMINGHAM.

BY PRODUCT PLANT FOR BENZOL - TAR - OILS SULPHATE OF AMMONIA. BENZOL STILLS TAR STILLS

PRESSED STEEL TANKS AND CONDENSERS RIVETTED PIPES.

TANKS FOR OIL STORAGE, GAS HOLDERS. WELDED PIPES

T & P & CO LD ATLAS WORKS BIRMINGHAM

COKE CARS COKE QUENCHERS COKE OVEN DOORS CAST IRON PREHEATERS HEAT EXCHANGERS. DEPHLEGMATORS.

ELECTRA ENGINES

SAVE TIME LABOUR & MONEY

7653

We are specialists in the manufacture of Internal Combustion Engines, and our Foundries for Ferrous and Non-Ferrous metals were organised to meet our own exacting requirements. Our Ferrous Foundry is so booked up that we cannot accept orders except for long-dated delivery — but we can give prompt delivery of Aluminium and Brass Castings at the present time.

ALUMINIUM AND BRASS CASTINGS

OF SUPERLATIVE EXCELLENCE to the finest limits AT KEENLY COMPETITIVE PRICES.

MOTOR TRADE WORK A SPECIALITY.

T. Q. JOHN, LIMITED, COVENTRY.

Manufacturers of "ELECTRA" Engines, &c.

VERTICAL BOILERS

SPECIALTY

Vertical Cross-Tube Boilers

FOR INDIA, AUSTRALIA, AND SOUTH AFRICAN MARKETS.

MARINE BOILERS

Not exceeding 7 ft. 6 in. dia. Any inspection and Tests.

Loco-type BOILERS

Multitubular ,,

Colonial ,,

Telegrams— "BOILERS, LOUGHBOROUGH."

Telephone— 51, LOUGHBOROUGH.

Code— A B C, 5th Edition.

WALTER W. COLTMAN & CO., LTD.,

Central Boiler Works, LOUGHBOROUGH.

7772

HIGH PRESSURE FANS

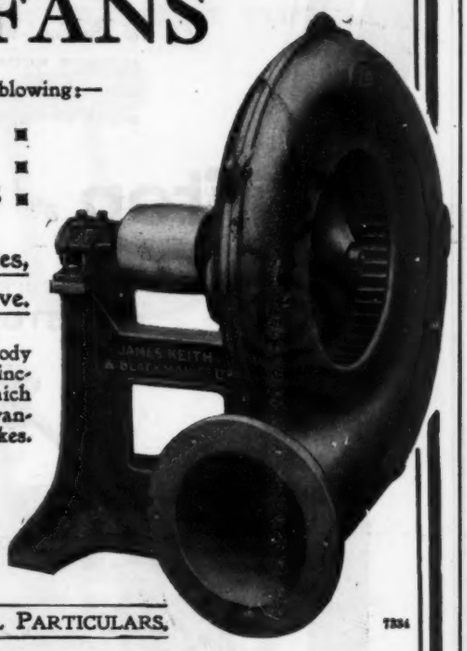
Extensively used for blowing:—

- FORGES
- CUPOLAS
- FURNACES

Made in all sizes, and for any drive.

These fans embody important and distinctive features which ensure many advantages over other makes.

Efficient.
Strong.
Economical



WRITE FOR FULL PARTICULARS. 7234

JAMES KEITH & BLACKMAN CO., LTD.,
27, FARRINGDON AVENUE LONDON, E.C. 4.

Hartness Flat Turret Lathe

The single spindle Flat Turret Lathe for chuck and bar work; the double spindle machine for chuck work only.

: QUICK : DELIVERY

May we have your orders now?

7715

JONES & LAMSON MACHINE CO.,
109, Queen Victoria Street,
LONDON, E.C. 4.

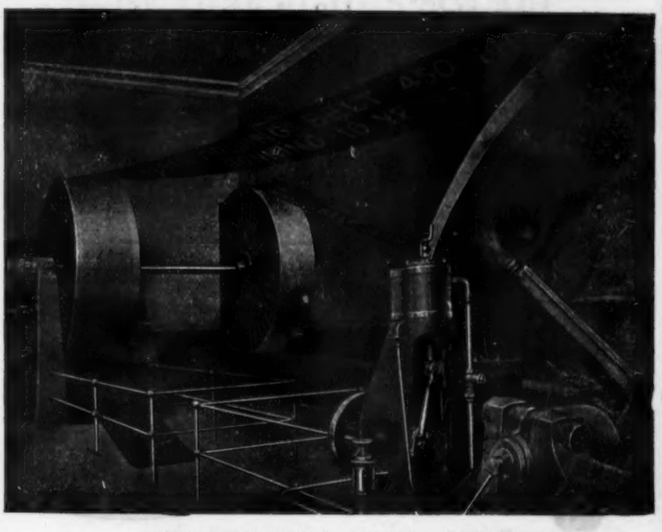
Telephone—722 City. Telegrams—Turretorum, Cent.

"CAMEL HAIR"

(REGISTERED TRADE MARK)

BELTING

UPWARDS OF 75,000,000 FEET SUPPLIED TO WORLD WIDE USERS.



WEAVING MILL MAIN DRIVE.

THE "CAMEL" BRAND BELTING

REGISTERED TRADE MARK

HAS AN UNBLEMISHED REPUTATION OF NEARLY 45 YEARS AS A MAIN DRIVING BELT, AND IS THE MOST SUCCESSFUL AND RELIABLE BELT IN THE WORLD.

Sole Makers:

F. REDDAWAY & CO., LIMITED,
PENDLETON, MANCHESTER. 7236

LONDON:
50-51, LIME STREET, E.C.

Quality & Price

Two Essentials for
:: :: Engineers :: ::

PIPE FITTINGS.
Malleable and Cast Iron,
Wrought Iron and Gun Metal
Hangers and Brackets.

VALVES & COCKS.
Iron or Gun Metal, Screwed & Flanged.

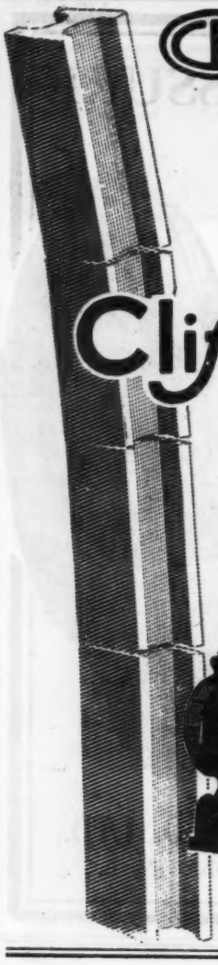
TOOLS.
Walworth and Hart's Diestocks,
Wrenches, Pipe Cutters, Vices, etc., etc.

Catalogue (illustrated) on application. 7691

H. MUNZING, Limited,

(DEPT. E.G.)

90-96, Union St.
LONDON, S.E.1.

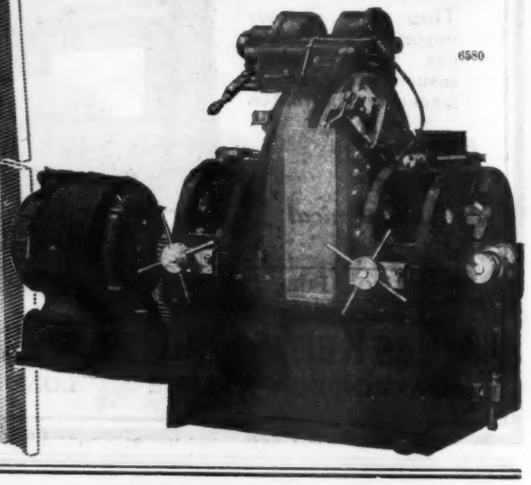


CB **This machine will cut solid metal bars at 5 times the speed**

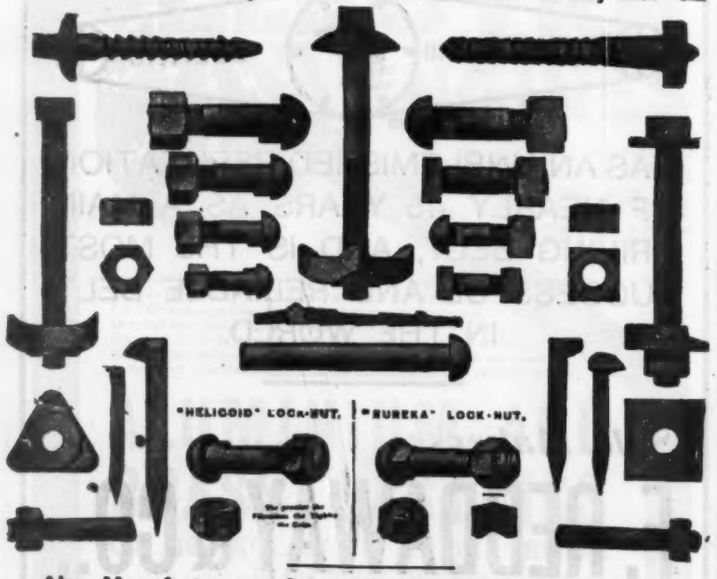
of Sawing Machines. It needs no expensive special machine for sharpening saws. It does the work better and saves money on current.

Clifton and Baird LTD

EMPRESS WORKS,
JOHNSTONE, SCOTLAND.



BAYLISS'S RAILWAY FASTENINGS, AND **BLACK & BRIGHT BOLTS & NUTS, &c.**

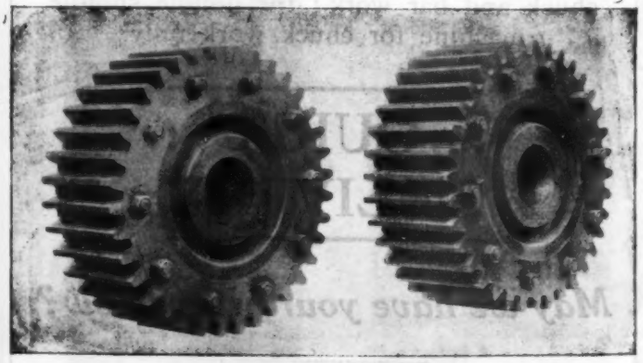


Also Manufacturers of Iron Fencing, Railings, Gates, &c., and IRON and STEEL BARS, Numerous Sections.
CATALOGUES FREE.

BAYLISS, JONES & BAYLISS,
LIMITED,
WOLVERHAMPTON. 4240
AND 139 & 141, CANNON STREET, LONDON, E.C. 4.

THE
REAY GEARWORKS, LTD.

SPECIALISTS IN RAW HIDE AND COMPRESSED PAPER PINIONS



Raw Hide Wheels, with Metal Centre and Steel Flanges, 24 in. diameter.

ALSO METAL AND STEEL WHEELS OF ALL DESCRIPTIONS.

7983

GATESHEAD-ON-TYNE.

GIBBON'S

IMPROVED ADJUSTABLE TYPIST'S SEAT

With PATENT ADJUSTABLE CLIP.

All Metal with the exception of the seat and back which are Polished Wood.

Metal Parts Stove Enamelled Black.

PRICE 40/- EACH.

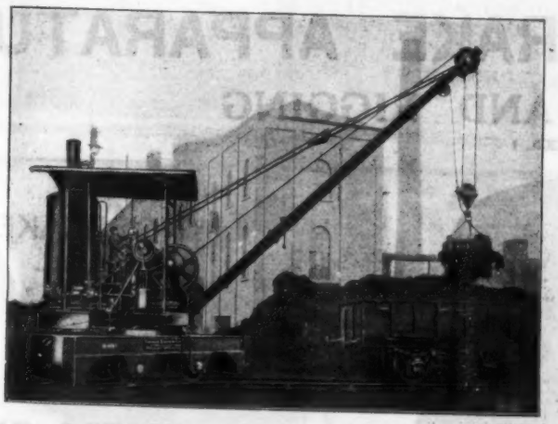
JAMES GIBBONS,

ST. JOHN'S WORKS,

WOLVERHAMPTON.

SMITH'S CRANES

THE MOST EFFICIENT & UP-TO-DATE.



MAGNET CRANE.—FIG. 838.

THOMAS SMITH & SONS (RODLEY) LTD.,

STEAM AND ELECTRIC CRANE WORKS, Od 5674

RODLEY, Near LEEDS.

Xmas

We are not such hardened business men—neither are you—as to deny that at this season of the year the whole atmosphere of Life is charged with the electricity of Goodwill. It envelopes us—it wraps us round—it fills every corner of our mind—carries our thoughts to every corner of the earth where we have friends, business or otherwise—in every sphere it is the same, and on or about the morning of the day when this message first appears in print we shall each of us wake up with those old familiar words upon our lips—

A Merry Christmas

And may every reader of "Engineering"—every customer of ours, past, present and prospective—share in that merriment and find therein a joyful pause in the arduous round of every-day activities.

JOHNSON & PHILLIPS, LTD.

Electrical Engineers and Cable Makers since '75,

CHARLTON, LONDON, S.E. 7.

City Offices: 12, Union Court, Old Broad Street, E.C. 2.

S. A. DANIELL LIMITED,

MACHINISTS, TOOL MAKERS AND IRONFOUNDERS,

EDWARD STREET, PARADE, BIRMINGHAM.

TELEGRAMS: "DANIELL, BIRMINGHAM."
A B C Code, 4th & 5th Editions.
Telephone Nos. 5405 and 5406 Central.

LONDON:
10, Camomile St., E.C.
GLASGOW: 17, Robertson Street.
MANCHESTER: 6, St. Mary's Gate.

7038

PATENT
(FULLY RELIEVED)
HAND-WORKING TAPS.

SIMPLEX PETROL, BENZOL OR PARAFFIN SHUNTING LOCOS.

Thoroughly efficient and reliable.

Hundreds of "Simplex" Locomotives in use.

They are built to stand up to the hardest work and have many advantages over Steam Locomotives.

Locos for all gauges.

40 B.HP. Simplex Petrol Shunting Locomotive.

Easy to handle and control.

Cheap to run and inexpensive to maintain.

We can give prompt deliveries.

Estimates on request. Please write, giving gauge, gradients and gross loads to be hauled.

7583

THE MOTOR RAIL & TRAM CAR CO., LTD., Simplex Works, BEDFORD.

IMPROVED VACUUM BRAKE APPARATUS.

"CRAB" CYLINDER AND RIGGING

(PATENTED.)

GREAT SAVING IN WEIGHT OF RIGGING.

BLOCK PRESSURES COMPENSATED.

NO BRAKE SHAFT.

VERTICAL STRESS ON UNDERFRAME ELIMINATED.

THE CONSOLIDATED BRAKE & ENGINEERING COMPANY, LTD.

16, DEAN'S YARD, WESTMINSTER, S.W. 1.

7583

Telegrams:—Vacuo, Vic, London. Phone:—Victoria 3987. Code:—A B C., 5th Edition.

TUBES LIMITED

WELDLESS TUBES for BOILERS and STEAM PIPES
LOCOMOTIVES & THE ENGINEERING & MOTOR TRADES. 3661

Works: ASTON MANOR, BIRMINGHAM.

Tele{grams: CYLINDERS. phone: No. 671 & 672 E (4 lines).

SHAFTING. 3677

'PHONE: GOVAN 653-654. TELEGRAMS: "PEDESTAL, GLASGOW."

GOVAN SHAFTING & ENGINEERING CO., LTD., GLASGOW.

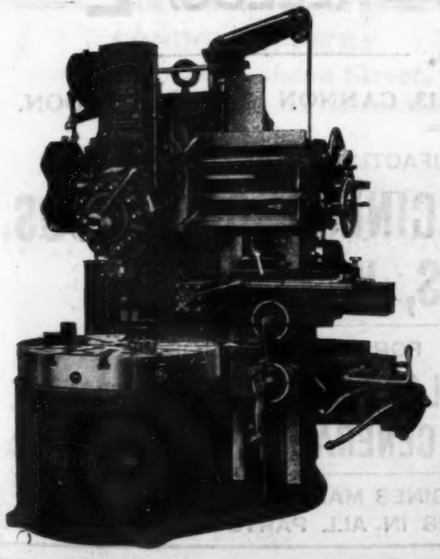
HAMMER HANDLES.

All Descriptions of Handles for Engineers' Tools manufactured by us from High Grade Material.

RIVETTING, STRIPPING, SLEDGE, HAND-HAMMER AND FILE HANDLES. 7641

ON ADMIRALTY LIST. LONG ROUND HOLDING-UP SHAFTS. CONTRACTORS TO WAR OFFICE.

GEO. DICKIE & SON, CHESTER STREET, BIRKENHEAD.



Time, Economy and BULLARD

The BULLARD Vertical Turret Lathe

Two tool-carrying heads operating at once—doubling production per man and machine.

The universal movement and adjustment of the two heads adapts the machine to a decidedly broad range of work with the use of standard tools.

Simplicity gained and time saved—is the big result of these advantages. Can you apply these time-saving features to your profit? Ask us. We will be glad to submit conservative estimates on your production with the Bullard.

Deliveries Are Good.

Sizes, 24 in., 36 in., 42 in., 54 in.

The Bullard Machine Tool Co.,

BRIDGEPORT, CONN., U.S.A. 7630

UPWARDS OF

200,000

GRESHAM'S PATENT

INJECTORS

OF ALL CLASSES NOW IN USE.

Telegraphic Address: BRAKE, MANCHESTER. Telephone: CENTRAL No. 618.

6514

GRESHAM & CRAVEN, LTD., MANCHESTER.

London: 110, Cannon St., E.C. Glasgow: W. Lester & Son, 11, West Regent St. Newcastle-on-Tyne: Tangyes, Ld. Paris: W. Strapp, 15, Rue de Madrid.

JOHN BROWN & COMPANY, LTD.

Atlas Works, SHEFFIELD; and CLYDEBANK, near GLASGOW.

LONDON: 8, THE SANCTUARY, WESTMINSTER, S.W.

BUILDERS OF PASSENGER AND CARGO STEAMERS,

And specially of First-class High-speed Ocean Steamers up to the Largest Size and Power.

WARSHIPS OF ALL TYPES

BATTLESHIPS, CRUISERS, AND TORPEDO BOATS

AS BUILT FOR THE

BRITISH, SPANISH, RUSSIAN, JAPANESE, AND NETHERLANDS GOVERNMENTS.

MANUFACTURERS OF 0 2614

ARMOUR PLATES and GUN FORGINGS.

HOLLOW ROLLED TURBINE ROTOR DRUMS, ROTOR SPINDLES, WHEELS, and DUMMY RINGS for TURBINE ENGINES

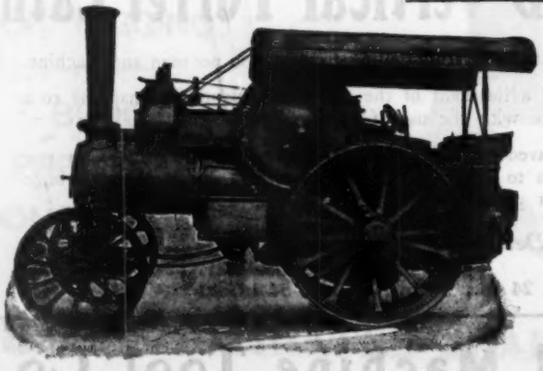
Largest Sizes of Crank and Straight Shafting, Hydraulic Pressed, Solid or Hollow, Rough Machined or Finished.

MARINE BOILER FURNACES. "ROBERT" and CRUCIBLE STEEL CASTINGS RAILWAY and TRAM TYRES, AXLES, SPRINGS, BUFFERS, &c. HIGH SPEED and OTHER STEELS.

JOHN FOWLER & Co. (LEEDS) LTD.,

ENGINEERS, LEEDS.

STEAM PLOUGH WORKS, LEEDS. — ENGLAND. — 113, CANNON STREET, LONDON.



THE LARGEST MANUFACTURERS IN THE WORLD OF

TRACTION ENGINES, ROAD LOCOS. ROAD ROLLERS, WAGONS, &c.

6813

SUITABLE FOR ALL KINDS OF

TRANSPORT, HAULAGE, THRASHING AND GENERAL FARM WORK, &c.

OVER 14,000 ENGINES MADE AND SUPPLIED.

CATALOGUES & ESTIMATES FREE ON APPLICATION. REFERENCES TO USERS IN ALL PARTS OF THE WORLD.

BEYER, PEACOCK & Co., Limited

London Representative:
E. S. LUARD, M.I.C.E.,
15, Dean's Yard, Westminster, S.W.
Tel. Address: "FOLGORE," Vic., London.
Telephone No. 3087 Victoria.

Gorton Foundry, Manchester.
ESTABLISHED IN 1854.

Works Telegraphic Address: { "LOCO," Gorton.
Telephone No. 255 Manchester, 8040, Genl. Manr. and Secy's Office.

LOCOMOTIVE ENGINES

FOR ALL PURPOSES AND GAUGES

GARRATT PATENT ARTICULATED LOCOMOTIVES

ALSO MACHINE TOOLS.

EMERY GRINDING MACHINES A SPECIALITY.

WITH OR WITHOUT ELECTRICAL DRIVE.

WORKMANSHIP AND MATERIAL UP TO THE HIGHEST STANDARD OF EXCELLENCE. 7482

STEEL FOUNDRY for Casting Wheel Centres and other Parts of Locomotives. Also general CASTINGS and FORGINGS

CLAYTON, SON & CO., LTD.

MOOR END WORKS, HUNSLET, LEEDS.

TELEGRAMS—"GAS, LEEDS." CONTRACTORS TO H.M. GOVERNMENT. LONDON OFFICE: 5, VICTORIA STREET, S.W.1.

WELDED AND RIVETTED **STEEL PIPES.**

BOILERS. GAS PLANTS. **TANKS** FOR OIL & WATER, &c. 7656

STRUCTURAL STEELWORK OF EVERY DESCRIPTION.

ICE & REFRIGERATING MACHINERY AND INSULATION.

Land Installations.

Carbonic Anhydride and Ammonia Compression Systems.

Marine Installations. 7335

THE LIVERPOOL REFRIGERATION COMPANY, LTD.

LONDON OFFICE:
London House, New London Street, E.C.

Contractors to H.M. Admiralty.
COLONIAL HOUSE, LIVERPOOL.

THE BUTTERLEY CO., LD.

DERBY. ESTABLISHED 1791.

Telephone—Nos. 15 and 16, RIPLEY. Telegrams—"Ironworks, Butterley."

Pig Iron, Bar Iron, Iron Castings up to **20 TONS.** 7097

Bridge and Structural Steelwork, Pit Trams, &c.
High-class Machine Work of all descriptions.
Special Acid-Resisting Metal for Chemical Plants.
Large Retorts, Pans, Acid Eggs, &c., a Speciality.

LONDON OFFICE—52, Queen Victoria Street. Telephone—2180 CITY.

Telegrams "WHITES, PENDLETON, MANCHESTER"

SUCCESSORS TO THOMAS H. WHITE
ESTABLISHED 1880

Telephone 58 PENDLETON

WHITE'S INJECTORS LIMITED.

THE GREATEST RANGE OF
INJECTORS AND EJECTORS IN THE KINGDOM.

MANCHESTER.

6767

ADMIRALTY WAR DEPARTMENT

HYDRAULIC LEATHERS

8142

THE BRITISH SPECIALISTS LEATHERS COMPANY (ALTRINCHAM) LIMITED, ALTRINCHAM

JAMES FAIRLEY & SONS, LTD.,
General Steel Manufacturers and SPECIALISTS in
Invite attention to their Unrivalled Self-Hardening Steel.

Contractors to His Majesty's and other Governments.

TOOL STEELS

FAIRLEY'S SELF-HARDENING TOOL STEEL, for Heavy Cuts at High Speeds,
is considered to be the HARDEST and TOUGHEST Steel yet made (although the Cheapest in the Market). Small samples free to approved buyers.
NOTE.—JAMES FAIRLEY & SONS, Ltd., Works (Bramall Lane, SHEFFIELD, & Mill St. Forge and Rolling Mills, BIRMINGHAM) are merely Branch Departments and
All Communications should be addressed to the Head Offices—OLD MINT, SHADWELL STREET, BIRMINGHAM. Od 1719

CONTRACTORS TO H.M. GOVERNMENT. ON WAR OFFICE, ADMIRALTY, INDIA OFFICE, and COLONIAL OFFICE LISTS. ESTABLISHED 1865.

THE BRANDON BRIDGE-BUILDING CO. LD.

ENGINEERS, BRIDGE-BUILDERS, IRONFOUNDERS.

7743

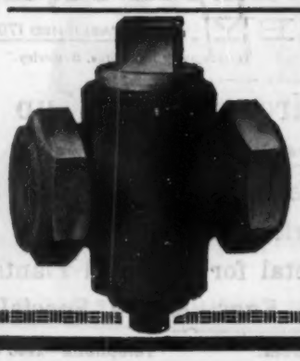
BRIDGES, ROOFS, DOCK GATES, TANKS, PIERS, LOCOMOTIVE TURNTABLES & WATER COLUMNS, PRESSED STEEL TROUGHING. INGOT MOULDS & GENERAL CASTINGS.

London Office:—
34, Victoria Street, Westminster.

Works:
MOTHERWELL.

Telegraphic Address: "GIRDER."
Telephone: No. 11.

CAST IRON MAIN COCKS



HIGH GRADE TESTED.

Clean Sound Castings. :: Perfect Workmanship.
Right Price. Right Quality.
Produced by Up-to-date Methods. :: Special Terms for Large Quantities.
Large Stocks on hand.

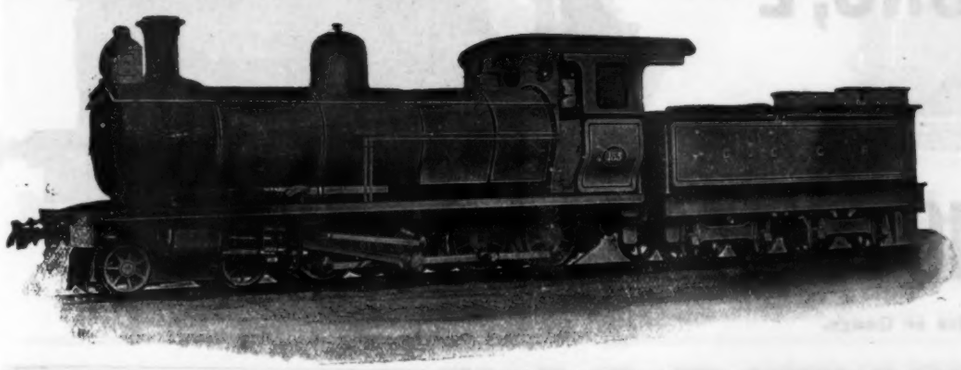
8064

H. B. WHITE & CO.,
Contractors to H.M. Government.
JOHN DALTON STREET :: :: MANCHESTER.
Telegraphic Address: "Whiteness, Manchester." Telephone: 5561 Central.

THE HUNSLET ENGINE CO., Ltd.,

LEEDS,

MAKERS OF



LOCOMOTIVE ENGINES

adapted to every variety of work and gauge.

Designs and Specifications supplied or worked to. 7168

Quotations and Specifications on application.

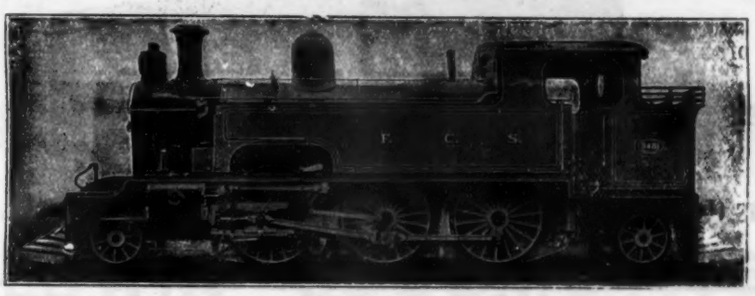
TELEGRAPHIC ADDRESS . . ENGINE, LEEDS.
TELEPHONE: 20677 (3 lines).

ROBERT STEPHENSON & CO., LIMITED,

Locomotive Builders, DARLINGTON.

ESTABLISHED AT NEWCASTLE, 1821. NEW WORKS OPENED AT DARLINGTON, 1902.

LONDON OFFICE:
Sanctuary House,
WESTMINSTER, S.W.
Telegrams—
ALTISCOPE, LONDON.
Nat. Telephone—
No. 650 VICTORIA.



WORKS:
Telegrams—
ROCKET, DARLINGTON.
Nat. Telephone—
2700.
Codes—
Engineering Standards, A B C (5th Edition), Engineering Telegraph (2nd Edition), and Kendall's.

1130

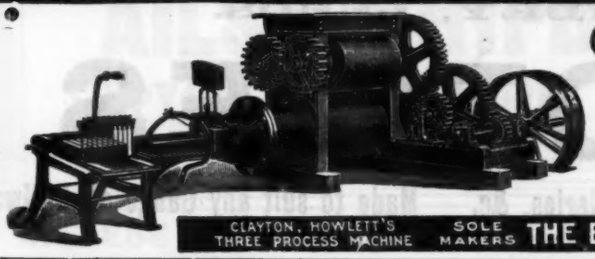
LOCOMOTIVES OF THE HIGHEST CLASS UP TO ANY SIZE AND CAPACITY.

Special Locomotives: Compound or Simple Expansion, Articulated, or other Types with Flexible Wheelbase to suite any Gauge of Rail and Conditions of Service.

TELEGRAMS "CASTINGS" SHEFFIELD

BRICK TILE & PIPE MACHINERY

TELEPHONES 373 & 1233



CLAYTON, HOWLETT & Cos AND MURRAY'S
(SIDNEY G.W. HUNTER & Co)
ILLUSTRATED CATALOGUE ON APPLICATION
LONDON OFFICE.
28 VICTORIA St WESTMINSTER, S.W.
Teleph: 920 VICTORIA. Telegr: "BRICK PRESS CAM" LONDON.

CLAYTON, HOWLETT'S THREE PROCESS MACHINE SOLE MAKERS THE BRIGHTSIDE FOUNDRY & ENGINEERING Co LTD SHEFFIELD

THE AVONSIDE ENGINE CO., LTD.

LOCOMOTIVE BUILDERS, BRISTOL, ENGLAND.

7236

PECKETT & SONS, LTD.,

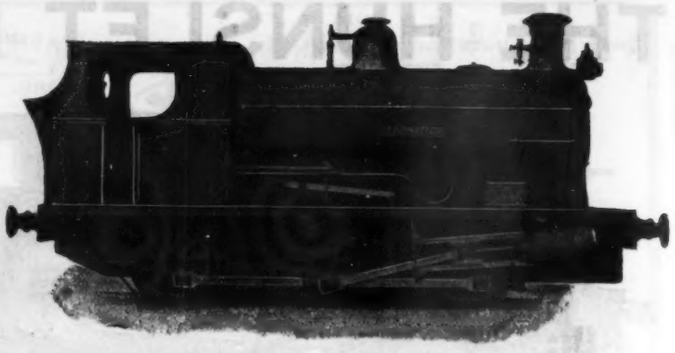
BRISTOL.

Telegrams . . . Peckett, Bristol.

SPECIALITY

TANK LOCOMOTIVES

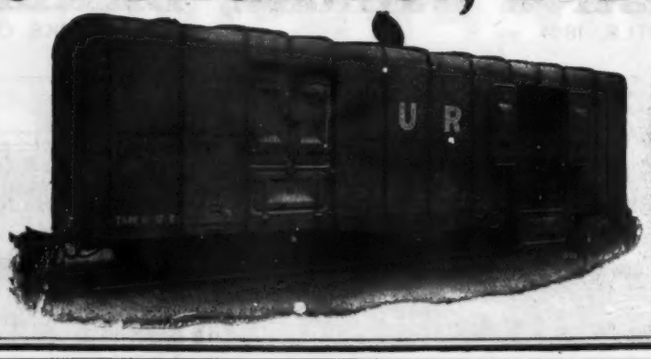
Of all Descriptions and any Size or Gauge.



6561 *Full Particulars on Application.*

THE LEEDS FORGE CO., LTD., LEEDS.

PIONEERS in the Design & Manufacture of PRESSED-STEEL UNDERFRAMES & BOGIES, and ALL-STEEL RAILWAY PASSENGER CARRIAGES and WAGONS.



7359

LONDON HOUSE—
38, VICTORIA STREET,
WESTMINSTER, S.W. 1.

UGANDA RAILWAY.

Covered Goods Wagon, with Fox's Pressed Steel Underframe and Bogies, and Lane's Patent Corrugated Pressed Steel Doors.

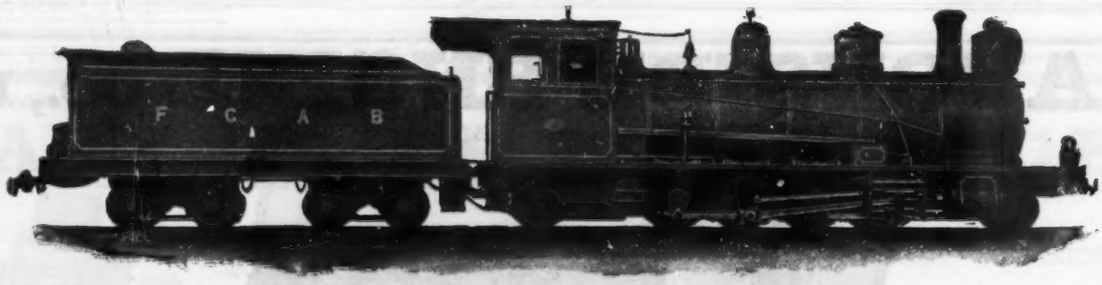
HUDSWELL, CLARKE & CO., LTD.,

RAILWAY FOUNDRY, LEEDS.

LOCOMOTIVES

For Main or Branch Railways, Contractors, Ironworks, Collieries, &c. Made to suit any Gauge of Railway.

Established 1860.



Tel. Address: "Loco, Leeds."

PRICES, PHOTOGRAPHS AND FULL SPECIFICATIONS ON APPLICATION.

7360

SOLE MAKERS OF

"RODGERS' PULLEYS"

(REGISTERED).

WROUGHT IRON THROUGHOUT, RIM, ARMS, AND BOSS.

MANNING, WARDLE & CO., Ltd., BOYNE ENGINE WORKS, LEEDS.

Makers of Locomotive Engines for any width of gauge and for all purposes. Also makers of Steam Rail Motor Coaches for passenger traffic. Materials and workmanship of the best quality. Tank Engines up to 18 in. cylinders, on four or six wheels, always in stock or in progress. Specifications, Photos and Prices on application, and Special Designs sent on receipt of particulars of requirements. Od 2486

London Office: Mr. H. J. HEAGERTY, Blenheim Mansions, Broadway, Westminster, S.W. 1.

BALDWIN

A Baldwin Locomotive for the Federated Malay States Railways.

The Baldwin products include steam locomotives for all classes of service; internal combustion locomotives for light switching and special service; and such engineering supplies as parts of heavy machinery, forgings, castings, boilers, tanks, in fact, anything that can be manufactured in a large locomotive building plant.

The Baldwin policy is to give the best possible service in all respects. As far as manufacturing, shipping and financing are concerned, we are prepared to accommodate our customers in every way.

The name "BALDWIN" is a world guarantee. 7805

THE BALDWIN LOCOMOTIVE WORKS,

Philadelphia, Pa., U.S.A.

LONDON OFFICE: 34, VICTORIA STREET, S.W. 1.

Cable Addresses: "BALDWIN PHILADELPHIA." "FRIBALD, LONDON."

AILSA SHIPBUILDING CO., LTD.,

SHIPYARD, ENGINE WORKS AND GRAVING DOCKS, TROON, N.B.

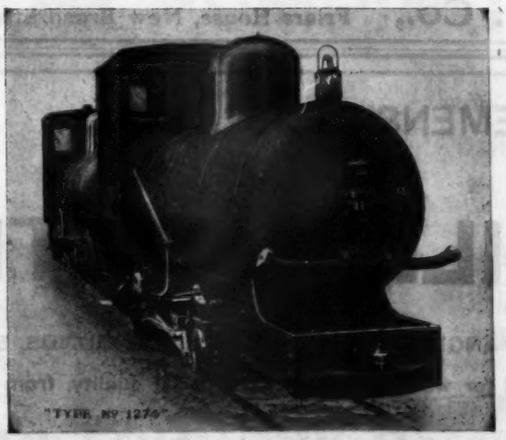
TELEGRAPHIC ADDRESS:—"SHIPYARD, TROON." TELEPHONE NO. 35 TROON.

8137 BRANCH SHIPYARD WITH HEAVY HAULING UP SLIPWAY AT AYR.

FIRELESS LOCOMOTIVES FOR EXPLOSIVES & POWDER FACTORIES.

MANY TYPES
FIRELESS LOCOMOTIVES
FROM 4'-8½" TO 2'-0" GAUGE
ALREADY SUPPLIED
TO MEET
DIVERSE CONDITIONS.
See Successive Illustrations.

TELEGRAMS—
"BARCLAYSON, KILMARNOCK."



COAL & OIL-FIRED LOCOMOTIVES.

CRANE LOCOMOTIVES.

ARTICULATED LOCOMOTIVES

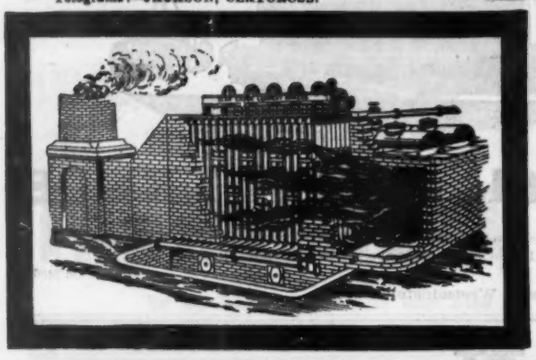
LONDON ADDRESS— 6826
53 VICTORIA STREET
WESTMINSTER S.W.

ANDREW BARCLAY, SONS & CO., Limited,

CALEDONIA WORKS, KILMARNOCK, SCOTLAND.

The Clay Cross Company, Ltd., Clay Cross, Derbyshire.

Telegrams:—JACKSON, CLAYCROSS. — ESTABLISHED 1837. — Telephone:—479 CHESTERFIELD.



MAKERS OF STANDARD-TYPE 7816

FUEL ECONOMISERS

For Utilising the Waste Heat from Steam Boilers of all Types.

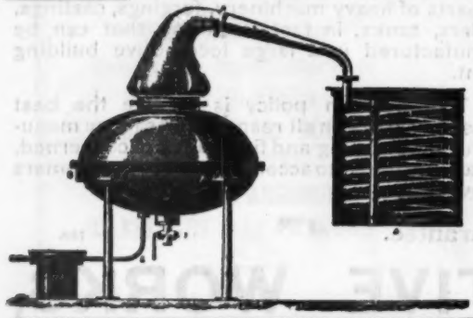
SAVES IN COAL FROM 15 TO 25 PER CENT.

Adopted by Steam Users throughout the World.

PONTIFEX & WOOD, Ltd.,

REMOVED from Farringdon Works, Shoe Lane, LONDON, to UNION FOUNDRY, DERBY.

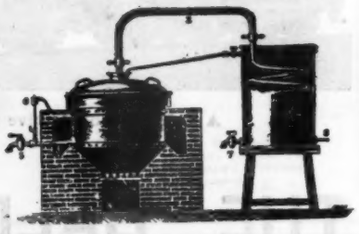
LONDON OFFICE: 175-177, SALISBURY HOUSE, LONDON WALL, E.C.

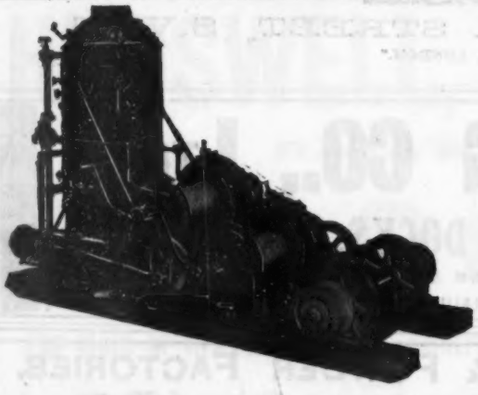


STILLS AND DISTILLING PLANTS

FOR ALL PURPOSES. Od 1448

Awarded Grand Prix, France-British Exhibition, London, 1908.





LIDGERWOOD HOISTS

STEAM — ELECTRIC — GASOLINE.

Built for speed. Contractors' work demands speed. A breakdown is a loss of time. Lidgerwood Quality insures both speed in operation and security against time lost by breakdowns. Whatever hoist you need we build it.

CABLEWAYS — DERRICKS — EXCAVATORS.

WRITE FOR CATALOGUES.

Lidgerwood Mfg. Co., Friars House, New Broad Street, London, E.C. 8541

Manufacturers of SIEMENS' ACID STEEL

BOILER PLATES.

Also SHIP and BRIDGE PLATES, ANGLES, BULBS, CHANNELS, ROUNDS, SQUARES, TEES, ZEDS, &c.

BILLETS, of dead soft quality, and for wire and springs or special quality, from any grade of carbon; also SLABS.

THE GLASGOW IRON & STEEL CO., LTD.,

WISHAW, SCOTLAND. 7843

CAMMELL LAIRD & CO., LD.,

SHEFFIELD and BIRKENHEAD.

STEEL MANUFACTURERS. SHIPBUILDERS. ENGINEERS. BOILERMAKERS.

LONDON OFFICE: 3, Central Buildings, Westminster, S.W.

SEE LAST WEEK'S AND NEXT WEEK'S ADVERTISEMENTS. 6684

T. M. Birkett & Sons Ltd.

BIRSO METALS

Manganese Bronze, Phosphor Bronze, Aluminium and Aluminium Alloys.

Gun Metal and Brass in the form of Ingots and Castings. Any grade of Anti-friction Metal.

We are Specialists in the manufacture of GLOBE WHEEL VALVES, RENEWABLE DISC VALVES, SOLID TAPER WEDGE, FULLWAY GATE VALVES, AND GLAND AND PLUG COCKS.

The BIRSO Brand is the best brand.

Gun Metal Steam Gland Cock.

We hold large stocks for prompt delivery.

T. M. BIRKETT & SONS, LTD., 4814

HANLEY, STAFFS, ENGLAND.

Gun Metal Wheel Valve

RAILWAY CARRIAGES
RAILWAY WAGONS
TRAM CARS, ETC.

MIDLAND RAILWAY-CARRIAGE & WAGON Co. LTD.

MIDLAND WORKS, WASHWOOD HEATH BIRMINGHAM.

LONDON OFFICE: 14, VICTORIA STREET, WESTMINSTER S.W.1 TELEPHONE No: 3371 VICTORIA TELEGRAMS UNDERFRAME, VIC, LONDON.

TELEGRAMS, "WAGON" BIRMINGHAM PHONE. No: 485-4-5 EAST.

GRAB-DREDGERS.

ROSE, DOWNS & THOMPSON, Ltd., HULL, LONDON and SHANGHAI.

ESTABLISHED 1777.

OIL MILLS. 7333

The DUBLIN DOCKYARD Co., LTD.

SHIPBUILDERS, ENGINEERS and REPAIRERS,

Alexandra Basin, North Wall, DUBLIN.

ALL MODERN APPLIANCES, including Electric, Pneumatic, and Oxy-Acetylene Plant for the QUICK REPAIR of

SHIPS, ENGINES, BOILERS.

Builders of all classes of VESSELS up to 300 ft., including HIGH-CLASS HOPPER GRAB DREDGERS.

Telegrams (Day or Night): "DOCKYARD, DUBLIN." ON ADMIRALTY AND WAR OFFICE LISTS. 4573 Telephones: Nos. 33 and 34.

DRY VACUUM PUMPING ENGINES

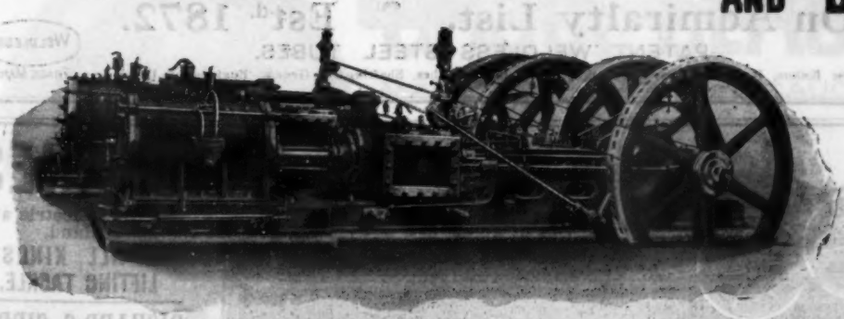
Slide Valve Type.

AND DRY VACUUM PUMPS

Belt, Steam or Motor Driven.

ALL CAPACITIES 20 TO 3,000 CUB. FT.

Single or Double Stage.



ALSO

HORIZONTAL AIR COMPRESSORS

FOR HIGH OR LOW PRESSURES.

Single or Double Stage.

Steam, Belt or Motor Driven.

7467

THE ANDERSTON FOUNDRY Co., Ltd.,

TELEGRAMS: AFCO, GLASGOW.
TELEPHONE: 6260 CENTRAL.

100 CHEAPSIDE STREET, GLASGOW.

BOILERS
LANCASHIRE & CORNISH TYPES
RIVETED & GENERAL PLATE WORK
SEE LAST WEEK'S ADVERTISEMENT

PURE WATER
for all purposes.
Particulars from 4361
The BUHRING'S Patent WATER PURIFYING Co.
2, Scrutton Street, E.C.

ELECTRICAL WIRES & CABLES
W. T. GLOVER & Co. Ltd.
TRAFFORD PARK · MANCHESTER
TELEGRAMS: CABLES, MANCHESTER.

STEAM LAUNDRY MACHINERY.
D. & J. TULLIS, Ld.,
Clydebank, N.B.
See our Advert. page 127, last week. 7008

KENNICOTT WATER SOFTENER Co.,
WOLVERHAMPTON.
Telephone—876, Wolverhampton.
Telegrams—"Waterlanks," Wolverhampton. 8073

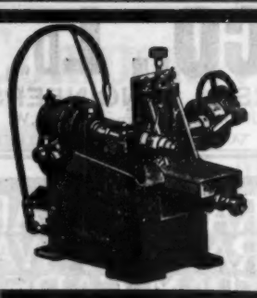
FOSTER BROTHERS, Limited,
TUBES & FITTINGS,
Main Steam Pipe Installations. 1042
WEDNESBURY.

J. PARKINSON & SON,
SHIPLEY, YORKSHIRE.
MANUFACTURERS OF
GEAR CUTTERS AND UNIVERSAL MILLERS

PRATCHITT BROTHERS,
PUMPING MACHINERY
DENTON IRONWORKS,
CARLISLE.

THE 8 IN. LATHE SPECIALISTS.
Catalogue by return on request.
SMITH, BARKER WILLSON & CO.
HALIFAX, Great Britain. 7509

THOMAS SHANKS & CO.
Johnstone.
FOR
HEAVY MACHINE TOOLS
SEE ILLUSTRATED ADVERTISEMENT ISSUE OF DEC. 5
7358



NEW MACHINE
for Generating
ACCURATE GEARING
for CLOCKS, WATER METERS, GAS METERS, ELECTRICITY METERS, &c.
MIKRON Ltd., Machine Works,
Madretsch, BIENNE, Switzerland.
(5865 H.)

HONE'S Patent
SINGLE-CHAIN WHOLE TYNE GRAB.
Highest Awards wherever Exhibited.
LABOUR-SAVING MACHINERY.
During the present shortage of labour, all Contractors and others handling materials, should adopt at once Hone's Patent Grabs, made in various types to suit requirements.
All particulars as to price, &c., may be obtained from the SOLE MANUFACTURERS: 5237
JOSEPH WESTWOOD & CO., Ld.
NAPIER YARD, MILLWALL, LONDON, E.
Telephone—East 4205 (4 lines). Telegrams—Westwood, Millwall, London

A LARGE FIRM OF
ENGINEERS
In London
ARE OPEN TO ACCEPT ORDERS FOR
TOOLS, JIGS,
PRESSINGS,
REPETITION WORK,
TURNING, MILLING, &c.,
SHEET METAL WORK.
— BOX No. 111. — C 111
MEERLOO PUBLICITY SERVICE,
106, New Bond Street, London, W. 1.

7341

THE WELDLESS STEEL TUBE CO., LTD.
Icknield Port Road, BIRMINGHAM.

TRADE MARK
On Admiralty List. 6941 Estd. 1872.
PATENT WELDLESS STEEL TUBES.
For Boilers, Hydraulic Presses, Ferrules, Boring Rods, Bushes, Shafting and General Engineering Uses.
WELDLESS. TRADE MARK.

CRANES,
Steam, Electric and Hand,
AND ALL KINDS OF LIFTING TACKLE.
RICHARD C. GIBBINS AND CO.,
Berkley St., Birmingham.
GLASGOW: Od 1891
JOHN S. BISHOP,
Corn Exchange Chambers, 29, Waterloo Street.

MOTORS-DYNAMOS

MAVOR & COULSON, LTD.
47, BROAD STREET, MILE END, GLASGOW.

Large stocks of all kinds of **SCRAP METALS**

INGOT METAL
To all Specifications.

CASTINGS
General Founders in Non-Ferrous Metals.

E. J. SMITH & CO., Metal Manufacturers and Merchants,
TELEPHONE / TELEGRAMS: ACOCKS GREEN. 208 & 209.
Tyseley Metal Works, BIRMINGHAM

THE STEEL PIPE COMPANY, LIMITED,

Telegraphic Address:— AQUILENTUS, KIRKCALDY.

KIRKCALDY.

Exhaust Pipes.
Water Mains.
Gas Mains.

Steel Chimneys.
Stamped Steel and Angle Flanges.

Special Pipes for Electric Stations.

LONDON AGENTS:—JOHN WILSON & CO., 39, Lime Street, E.C.

ESTABLISHED 1853.

GAUGE GLASS PROTECTORS.

"EUREKA" GAUGE GLASSES

MAKERS OF THE NEW GAUGE GLASS
"S. H. P."
FOR SPECIAL HIGH-PRESSURE BOILERS.

STEAM GAUGES

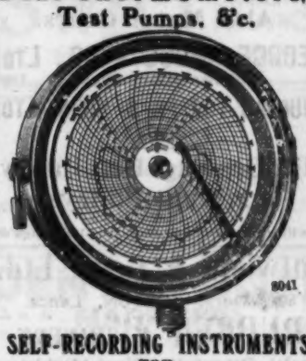
PRESSURE and INDICATING GAUGES of all Descriptions.

JOSEPH TOMEY & SONS, LTD., ASTON, BIRMINGHAM.
London Office and Warehouse: 5, Exchange Parade, Southwark St., London, S.E.

BUDENBERG GAUGE Co. LTD

(Late Schaffer & Budenberg Ltd.)
BROADHEATH Nr. MANCHESTER.
BRANCHES: LONDON & GLASGOW.

Makers of
PRESSURE GAUGES, Tachometers, Counters, Dial-Thermometers, Test Pumps, &c.



SELF-RECORDING INSTRUMENTS FOR PRESSURE, TEMPERATURE and SPEED.

"BUFFALO" INJECTOR.

Operated Entirely by One Handle.

Class A lifts 26 ft.
Class B lifts 13 ft.

Send for List.

Telegrams: "TEMPERATURE, LONDON."
Telephone: 04 3428

Green & Boulding, LIMITED, 22, New Bridge St., LONDON E.C. 4.

VICKERLINE

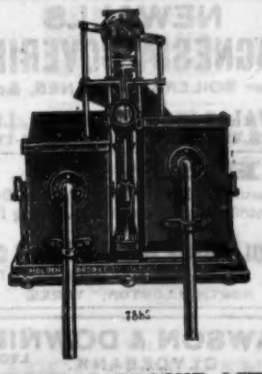
BENJN. R. VICKERS & SONS, LTD. LEEDS.

SOLIDIFIED OIL FOR Tunnel Bearings.

No Resin.
No Gumming.
A PURE GREASE.

LIQUID METERS

For Measuring all Liquids by Weight.



HOLDEN & BROOKE, LTD.,
SIRIUS WORKS,
MANCHESTER.

Rd. White & Sons, Widnes,
FOR **RAILS,** Lancs. 7817
POINTS AND CROSSINGS.
AERIAL ROPEWAYS.

RAW HIDE GEARS
Also Metal Gears.
GEORGE ANGUS & CO., LTD.
Newcastle-on-Tyne. 7366

DOUGLAS FRASER & SONS, LTD.,
ARBROATH.
Mill Gearing, Belt Pulleys and Rope Pulleys. 7735
See illustrated advertisement, Dec. 19th, page 60.

Entwisle & Gass, Ltd.,
Engineers, BOLTON, Lancs.
RUBBER MACHINERY.
Special Patent Washing Machinery for Plantation Use. 1192

DIESEL ENGINES
(POLAR TYPE)
FOR ALL PURPOSES
(Land and Marine).
See Illustrated Advert. last and next week. 8051

THE ANDERSON-GRICE CO., Ltd.,
CARNOUSTIE, FOR **CRANES** 7256
See Our Illustrated Advertisement of last week.

SANKEY
Foundry Ladles
Pressed Steel
Joseph Sankey & Sons Ltd
Wellington Shropshire

MACHINE TOOLS
for Shipbuilders and Iron & Steel Works
BERTRAMS LIMITED
EDINBURGH

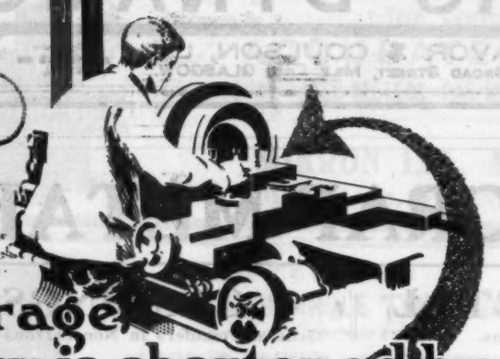
THE BEST
MELDRUM FURNACES, STOKERS, DESTRUCTORS, SUPERHEATERS.
Canal Werks, Gorton, MANCHESTER.

NEWALLS 7916
MAGNESIA COVERING
For BOILERS, TURBINES, &c.
NEWALLS INSULATION Co., Ltd.,
81, MOSLEY STREET, NEWCASTLE-ON-TYNE.

PUMPS.
Direct-acting, Feed, Air and Service Pumps, Duplex and Centrifugal Pumps, Auxiliary Condensing Plant.
NICHOLS PUMP & ENGINEERING CO., LTD.
(Late NICHOLS BROS.)
NORTHALLERTON, YORKS. 7431

DAWSON & DOWNIE, LTD.
GLYDEBANK.
PUMPS 7399
FOR LAND AND MARINE PLANTS.
SEE ILLUSTRATED ADVT., PAGE 101, Dec. 19.

The life that's built into the average lorry is shortened by neglect when it's in use



HOW many users of a motor lorry really obtain full value from their purchase? How many are there whose vehicles do *not* depreciate quicker than they need do? Indeed there are few. And the reason is that in most lorries those parts which have to stand the hardest *wear* and *tear* and *should* be given most attention are inaccessible, or, at any rate, so difficult to get at that they're left alone—till something happens—that something often meaning that the vehicle will be out of action for a costly period. But the vital parts of a

MAUDSLAY

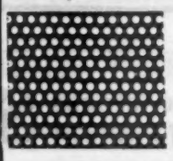
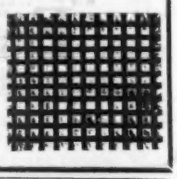
Lorry are rarely neglected for the simple reason that they are so easily get-at-able. Maudslay accessibility is unequalled, and in consequence a Maudslay's seldom—*very* seldom *laid* up, and with reasonable attention—attention *that does not* entail fatigue or time, will last its *owner* as few other vehicles on the market will do.

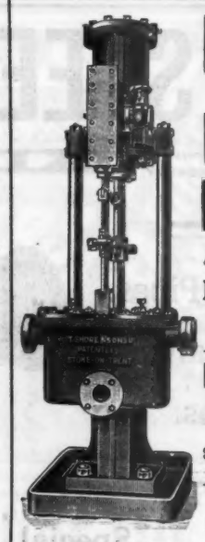
MAUDSLAY MOTOR Co., Ltd.
COVENTRY.
4563

PRINCIPAL AGENTS:—BIRMINGHAM—John Chilton and Co., 71, Broad Street. BURNLEY—G. E. Duerden, Olympia Motor & Engineering Works. EDINBURGH—The Scottish Motor Traction Co., Ltd., East Fountainbridge. MANCHESTER—Leach and Seed, 16, John Dalton Street. LIVERPOOL—Leach and Seed, Imperial Buildings, Exchange Street East. NOTTINGHAM—R. Cripps & Co., Ltd., Lower Parliament Street. BELFAST—A. Stringer, 156, Antrim Road. CARDIFF—W. Lewis and Sons (Cardiff), Ltd., Clare Street. BRISTOL—Windmill & Lewis, Ltd., Victoria Street, Clifton.

AUSTRALIAN REPRESENTATIVE.
Fredk. Inman, P.O. Box 606, Melbourne.

KELVIN ENGINES
STATIONARY TYPES FOR DRIVING AIR COMPRESSORS, PUMPS, &c.
The Berglus Launch & Engine Co., Ltd., GLASGOW. 7763
See Illustrated Advt. Last Week or Next.


PERFORATED METALS.
G. A. HARVEY & Co. (London), Ld.
WOOLWICH ROAD, LONDON, S.E. 7.
City Office—
SUFFOLK HOUSE, LAURENCE POUNTNEY HILL, LONDON, E.C.4
WOVEN WIRE.

7976


PUMPS
FOR
BOILER FEEDING
AND OTHER IMPORTANT DUTIES.
MINE PUMPS
a Speciality.
ONE OF THE SIMPLEST VALVE GEARS ON THE MARKET.
SEND US YOUR ENQUIRIES.
7850
THOS. SHORE & SONS, LTD.,
ETRURIA, STOKE-ON-TRENT.

WELDED WORK
Tubular Transformer Tanks.
Switch Tanks.
Elevator Buckets.
Steam Jacket Pans.
Hardening Pots.
Water, Petrol and Oil Tanks.
Plating Vats. 8012
General Welded Work.
Copper Pans, Cylinders, &c.
Welded Boilers for Hot Water Supply & Heating Apparatus.
R. JENKINS & Co., Ltd.
(Est. 1806) ROTHERHAM.

Contractors to the Admiralty, War Office, India Office and Crown Agents for the Colonies for every kind of
SPRINGS
SMITH BROS. & HILL, LTD.
(See displayed Advt. every fourth week 7559
Albert Spring Works, West Bromwich.

THE "STONE" SYSTEM
OF
HYDRAULICALLY OPERATED
WATERTIGHT DOORS.
As fitted to latest Mail and Passenger Steamers.
J. STONE & CO., LTD.
Deptford, London, S.E. 7699

FOR
WATER SOFTENERS, &c.,
APPLY TO— 8085
The Harris Patent Filter (1910) Ltd.
24, Grainger Street West,
NEWCASTLE-ON-TYNE.

H.W. WARD & Co., Ld.
Lionel Street, BIRMINGHAM. 5443
MACHINE TOOLS
Telegrams—Tudor, Birmingham. Tel. No. 7460 Central.
See illustrated Advertisement last and next week.

Machine Cut Gear Wheels
THE REID GEAR CO.,
7961
LINWOOD, near PAISLEY

GUNMETAL
SCRAP
bought or re-melted into castings.
HUNT & MITTON, Ltd.,
ENGINEERS' BRASSFOUNDERS, 6550
Ozells Street North, BIRMINGHAM.

THE BRITISH ELECTRIC PLANT CO., LTD., 6439
See Monthly Advt. of
TURBINE PUMPS,
DYNAMOS,
MOTORS.
66, CARRICK ST., GLASGOW.

The Rahn-Larmon Co.,
MANUFACTURERS OF
ENGINE, TURRET and GAP
LATHES. 7268
Cincinnati, O.

CLYNE ENGINEERING CO., LTD.
Telegrams: "MODERNIZE." Tele. No. 4070 CITY.
WATER COOLERS, CONDENSING
PLANTS, VACUUM PUMPS
AND COMPRESSORS,
STEAM TRAPS, &c. 1451
94, MARKET ST., MANCHESTER.

AITON & Co. LTD. DERBY
MAKERS OF FLANGED PIPES
CAST-IRON, STEEL, COPPER
FOR STEAM, WATER & GAS
See large advert. Dec. 5. 6731

Go to Clarke's Crank & Forge Co., LINCOLN Ltd
FOR CRANKSHAFTS AND FORGINGS
and to 8033
The Farrar Boilerworks Ltd., Newark
FOR BOILERS AND RECEIVERS.
See full page advertisement other weeks.

"LEA" RECORDERS
FOR MEASURING
BOILER FEED WATER
AIR PUMP DISCHARGES, ETC.
THE "LEA" RECORDER CO., LTD.
28, DEANSGATE, MANCHESTER.

COAL SAVING
BY SCIENTIFIC METHODS
IN THE BOILER HOUSE.

REORGANISATION.

IT IS AGREED THAT SOME OF OUR NATIONAL BUSINESS METHODS ARE IN URGENT NEED OF REORGANISATION. WE SUBMIT THAT IN THE AVERAGE FACTORY, ONE OF THE MOST IMPORTANT REFORMS, LONG OVERDUE, IS THAT OF THE BOILER-HOUSE.

THE PRESENT METHODS OF STEAM GENERATION ARE OUT-OF-DATE. WE HAVE SHOWN THAT THE AVERAGE EFFICIENCY OF THE BOILER-PLANTS OF GREAT BRITAIN IS ONLY ABOUT 60%, AND WE CAN REORGANISE YOUR BOILER-PLANT TO RUN ON AN EFFICIENCY OF 75% UNDER AVERAGE CONDITIONS, REPRESENTING 15-25% SAVING IN THE COAL BILL.

We offer you our services as Scientific Specialists in this business with 10 years' continuous experience including every description of boiler-plant in almost every industry.
WE HAVE A UNIQUE ORGANISATION INCLUDING A STAFF OF TRAINED ENGINEERS, LABORATORIES AND TESTING STATION, AND BUILDING DEPARTMENT FOR HANDLING ALL BUILDING AND FOUNDATION WORK.

We shall be pleased to supply full particulars on application, either personally or by letter, and are prepared to visit your Works **free of charge**, and give you our opinion of the working of your boiler plant.

Brownlie & Green, Ltd.
TECHNICAL CHEMISTS AND ENGINEERS,
Specialists in Fuel Economy,
2, AUSTIN FRIARS, LONDON, E.C. 2.
Telephone - - - 6292 London Wall.
GLASGOW - - - 94, Hope Street.
LABORATORIES AND TESTING STATION,
Church Street, Cheetham, Manchester.
7926

FILTERS
For Water, Waste Oil, &c., 7643
FREDK. LIPSCOMBE & CO.,
84, ALBERT BLDGS., LONDON, E.C. 4.

SWIFT LATHES & DRILLING MACHINES
GEORGE SWIFT & SONS LTD
CLAREMONT IRON WORKS
HALIFAX - ENGLAND.

A. Reyrolle & Co., Ltd
7871
Switchgear. Hebburn-on-Tyne.

CENTRIFUGAL
MACHINES.
Catalogues free on application. 7239
WATSON, LAIDLAW & CO., Ltd.,
Engineers, GLASGOW.

A FIRM GRIP OF THE PULLEY
"Cling-Surface BELT TREATMENT
THOMAS & BISHOP, Ltd.,
37, Tabernacle Street, London, E.C.2.

8078

CHARMOUTH ST, LEEDS.

GLENFIELD & KENNEDY LTD.
Engineers & Ironfounders,
KILMARNOCK, 7890
SCOTLAND.
SEE ADVT. LAST AND NEXT WEEK'S ISSUE.

JOHN SPENCER, LD.
7870 WEDNESBURY.
IRON & STEEL
TUBES
POLES, STEAM MAINS, TUBULAR PILES, &c.

MARINE ENGINEERS
AND BOILER
MAKERS.
DAVID ROWAN & Co., LD. 6859
231, Elliott Street,
GLASGOW.
Telegrams—"ROWAN, GLASGOW."
Cable Codes—A B C (4th & 5th Editions). LIEBER'S.

GAS PRODUCERS.
STEEL FURNACES.
SHELL FURNACES.
See last week's Advertisements. 7229
Send for particulars to—
G. P. WINOOTT, LTD.,
180, ATTERCLIFFE ROAD, SHEFFIELD.

Paterson
WORKS SUPERINTENDENCE SPECIALISTS
7756

THE
VAUGHAN CRANE
Co., Ltd., Manchester.
Travelling Cranes—Runways—Pulley Blocks.

THOMAS BOLTON & SONS, LTD.

Established 1783.

COPPERSMELTERS & MANUFACTURERS.

Contractors to His Majesty's Government.

BRASS

TUBES, PLATES, SHEETS, WIRE, RODS.

Singe Plates
Manganese
Copper Rods

7598

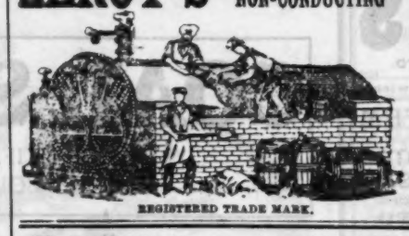
WORKS—

OAKAMOOR, NORTH STAFFORDSHIRE. FROGHALL, NORTH STAFFORDSHIRE.
MERSEY COPPER WORKS, WIDNES. BUTTON ROLLING MILLS, ST. HELENS.

LONDON OFFICE: 57 Bishopsgate (W. Lee Mathews, London Director)

Telegraphic Address:—WIREDRAWN, LONDON.

LEROY'S Improved Patented NON-CONDUCTING COMPOSITION



REGISTERED TRADE MARK.

FOR COATING BOILERS, STEAM PIPES, &c., to prevent the radiation of heat, save fuel, and increase the power of steam. IT WILL AT ONCE SHOW a LEAK. IT CANNOT CATCH OR COMMUNICATE FIRE.

In London the cost of the Covering is saved in about six months.

May be seen where it has been in use 20 years.

ESTABLISHED 1865. 7966

F. LEROY & CO.,
20, Gray St., Commercial Rd., London, E.
Also at MANCHESTER.

JOHN OAKEY & SONS, Ltd.

GENUINE EMERY, EMERY WHEELS
EMERY CLOTH, For all Purposes.
Wellington Mills, GLASS & FLINT PAPERS,
WESTMINSTER BRIDGE ROAD, 1296
LONDON, S.E. 1. BLACK LEAD, &c.

OXYGEN FOR THE CUTTING and WELDING OF METALS.

If you are not yet making use of Oxygen for Cutting, and the Oxy-Acetylene Welding Process, or wish to hear of the latest improvements in both, write to the British Oxygen Company. 7989

THE BRITISH OXYGEN COMPANY, the Founders of the Oxygen Industry, have highly-equipped and up-to-date factories in all the important British industrial centres capable of producing over

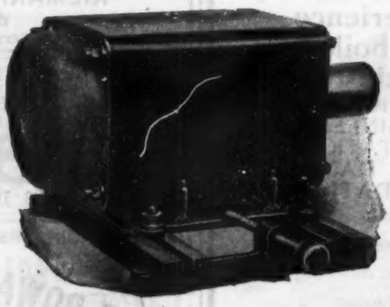
1,500,000 Cubic Feet of OXYGEN DAILY.

The Company are the foremost Manufacturers in Great Britain of Oxygen Metal Cutting Apparatus, Oxy-Acetylene, Oxy-Hydrogen, and Oxy-Coal Gas Welding Blowpipes, High Pressure Gas Regulators, &c.

For Catalogues and Full Particulars apply to any of the Company's Works

Elverton St., Westminster, S.W. North Wembley, Middlesex.
Tunnel Av., East Greenwich. Shields Rd., Walker Gate.
Newcastle Lower Walsall St., Wolverhampton. Saltley.
Birmingham. Terry Rd., Coventry. Gt. Marlborough St.
Manchester. Rosehill, Polmadie, Glasgow. East Moors, Cardiff.
Savile St., Sheffield. Bromborough Port, near Birkenhead.
Warton Rd., Stratford, E.

THE BRITISH OXYGEN CO., Ltd.,
ELVERTON STREET, WESTMINSTER, LONDON, S.W.1.



L-W Electric Motors.

A line of high efficiency (mechanical and electrical) small motors embodying all the latest war research work which is standardised and produced in quantities at a price no higher than older and less efficient designs.

7354

It will pay you to write for particulars.

Arthur Lyon & Wrench, Ltd.,
36, Victoria Street, Westminster, S.W. 1.
Tele: Vict. 2543. Works at Willesden Junction.

"NATIONAL" Fusible Plugs

ARE THE BEST AND MOST

Reliable LOW-WATER SAFEGUARD

IN THE MARKET.

Suitable for All Classes of Internally-Fired Boilers.

Special Plugs for High Pressures.

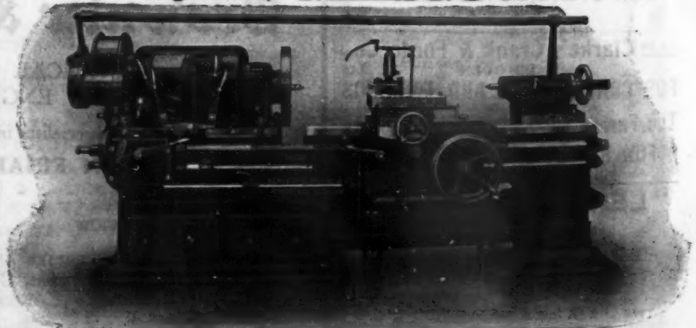
THE NATIONAL BOILER AND 7545
General Insurance Co., Ld.,
St. Mary's Parsonage, MANCHESTER
London: 60, Queen Victoria Street, E.C.

Screwed 1 in. 1¼ in. 1½ in. and 2 in. Gas Thread on the Seating.

Illustrated Price List Free.

DEMPSTER, MOORE & CO., LTD

Engineers, GLASGOW.



From photo of 8½ in. Lathe. 8117

SPECIALITY:—NEW TYPE LATHES FOR HEAVY CUTTING.

HYATT ROLLER BEARINGS

Suitable for all applications.

See our displayed advertisement next week.

(CATALOGUE "E") 8120

HYATT Ld., 24, DEVONSHIRE STREET, LONDON, W.C. 1.

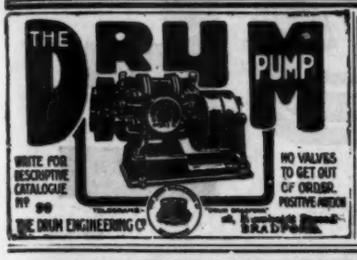
Wires—"Hyrodlim, Phone, London" 'Phone—Museum 3745

The TIMBRELL & WRIGHT MACHINE TOOL & ENG. CO., Ltd., Slaney Street, Birmingham.

T. & W. CAPSTAN LATHES.

See our Fortnightly Advertisement. 6900

THE DRUM PUMP



WRITE FOR DESCRIPTIVE CATALOGUE No 99

NO VALVES TO GET OUT OF ORDER. POSITIVE ACTION

THE DRUM ENGINEERING Co

Established 1845.

SUMMERS & PAYNE, Ltd.,

SOUTHAMPTON.

Ship and Yacht Builders,

ENGINEERS AND REPAIRERS.

BUILDING BERTHS up to 200 ft.

Wires:—"PAYNES', SOUTHAMPTON."

London Dept.: 8120

Mr. A. ROBERTSON, 23, Leadenhall Street

HIGH GRADE — CASTINGS — QUICK DESPATCH. 7820

In Iron, Malleable Iron, Steel, Brass, Gun Metal.

PENNEY & CO. LTD., Engineers & Founders, LINCOLN.

HAMMERED CAST IRON PISTON RINGS

(by the Davy-Robertson Process).

All sizes from 2½ in. to 72 in.

In our Special Piston Ring Iron.

Quick Delivery. Low Prices.

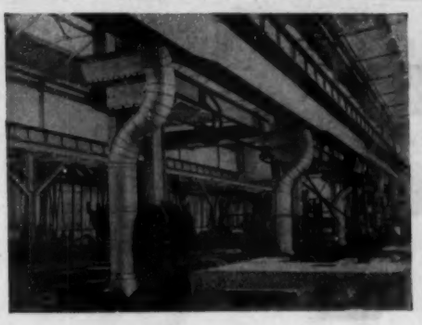
The Standard Piston Ring & Engineering Co., Ltd.,

Premier Works, Don Road, SHEFFIELD.

7381

Telephone: No. 2149.

Telegrams: Ocean, Sheffield.



Warm Your Shops

with the Sturtevant System.

It is independent of weather conditions and circulates a supply of fresh warm air throughout the building.

It secures better working conditions and increased efficiency.

It is economical, as the same plant can be used for ventilating in the summer.

We shall be pleased to give full information on our Warming, Ventilating & Air Washing Systems.

Illustrated Publication D. 1121 sent on request.

Sturtevant 7290

Engineering Co., Ltd.,

147, Queen Victoria St., London.

This Stamp

must be becoming familiar to you. You have seen it on many letters you receive, many of you have seen it so often that possibly the message which it carries is not so forceful to-day as it was when first it came before your notice.

Well, we ask you to look again—to read it carefully—to book the date, for on such date there will be opened the finest Exhibition of British Empire Products which has ever been held anywhere.

And remember, that Exhibition represents a National effort, and that visitors thereto will be able to conduct their business in the right atmosphere, and undoubtedly by being present will materially enhance their own success and that of British Commerce generally.

All Details from General Manager,

British Industries Fair (B'ham.) 1920,

Chamber of Commerce,

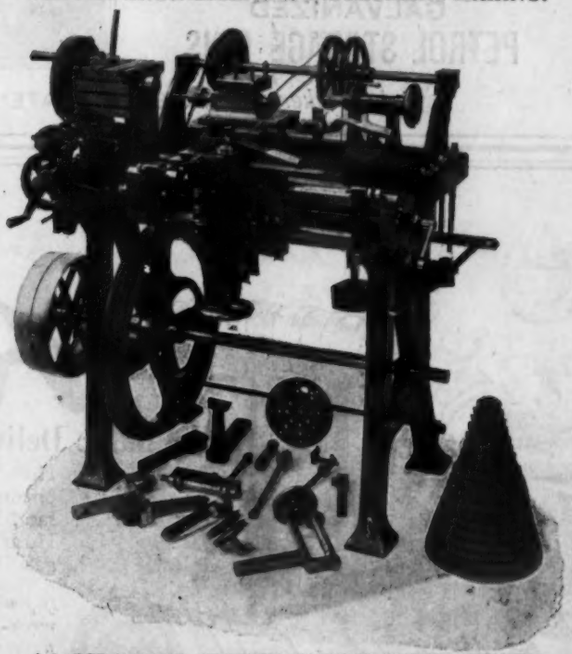
BIRMINGHAM.

8000AA

A UNIVERSAL MILLING & SHAPING MACHINE

for

PRECISE ENGINEERING & INSTRUMENT-MAKING.



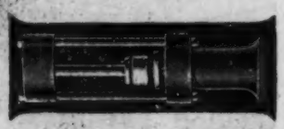
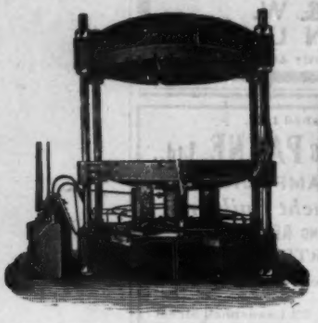
A LARGE NUMBER OF THESE MACHINES MAY BE SEEN IN OPERATION ON A VARIETY OF WORK IN OUR OWN SHOPS.

(Send for Pamphlet, mentioning "ENGINEERING.") 7805

T. COOKE & SONS, LTD.,

ENGINEERS AND SCIENTIFIC INSTRUMENT MAKERS.

BUCKINGHAM WORKS, YORK.

R   E

8870

Nat. Telephone: 2362. ***Telegrams: PRESS, LEEDS.*** ***Code: A B C 5th Ed.***

LONDON OFFICE:
3, St. Helen's Place, E.C. 3.
Telegrams:
"PROMPTITUDE, LED, LONDON."
Telephone:
AVENUE 5113 & 5114.

BALDWINS LTD

LONDON WORKS:
Orchard Place, Blackwall, E.
Telegrams:
"SILVERINE, POP, LONDON."
Telephone:
EAST 1074 & 1075.

MANUFACTURERS OF ALL KINDS OF

TANKS, CISTERNS, CYLINDERS, &c.

GALVANIZED CORRUGATED SHEETS.

DRUMS, KEGS, CANS, &c.

GALVD. CORN BINS.

GALVANIZED PETROL STORAGE BINS.

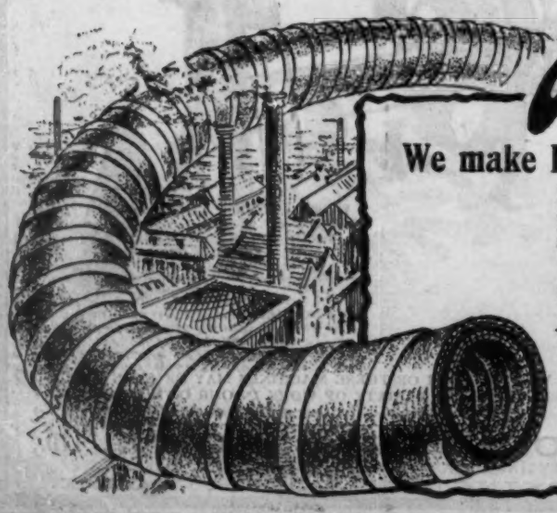
GALVANIZED FLAT WORKING-UP SHEETS.

C.R. & C.A. BLACK SHEETS.

GALVANIZERS of all kinds of IRONWORK.

8087

Sole Makers of LEECH'S PATENT WELDED CISTERNS, SINKS, TROUGHS, &c.



Rubber Hose

We make Delivery, Suction, Steam and Hydraulic Hose

Hose for oil, oil-gas, petrol, sewage, oxy-acetylene plant, pneumatic hammers, riveters, &c., rock drills, vacuum cleaners, sand blast apparatus, dredging and salvage.
Hose for railway work, including air, vacuum and steam brake pipes; gas-filling and steam-heating hoses, feedpipes, boiler washout pipes.

If you are in the Market for Hose, write for our List No. 1. You will find we can supply your exact requirements.

Silvertown

The India Rubber, Gutta Percha & Telegraph Works Co., Ltd.
(The Silvertown Company).
Head Office—106, Cannon Street, London, E.C. 4. Works—Silvertown, London, E. 16

Thomas Hunt & Sons, Engineers and MILLWRIGHTS, Albion Iron Works, Bridge Road West, Battersea, S.W. 11, undertake the MANUFACTURE of ALL KINDS of MACHINERY. Repairs and Breakdowns promptly attended to. 7976

To Travellers in the Nut and Bolt Line (Bright Steel) first quality. WANTED AT ONCE, MEN doing large turnovers. Especially liberal terms to those who can book big orders straightaway for immediate delivery.—Address, Z. L. 258, care of DEACONS, Leadenhall Street, E.C. 3. C 497

Engineering Works, Glasgow East, with modern PLANT FOR TURNING, boring and facing, screwcutting, milling, grinding and drilling, is DESIROUS of being PUT IN TOUCH with firms having ORDERS TO GIVE OUT. High standard of ACCURACY and FINISH guaranteed.—Address, KENNEDY'S (CARNTYNE) LTD., Carntyne, Shettleston, Glasgow. 7702

Machine Work Wanted.—Turning, Boring, Grinding and Milling done to accurate limits. Complete Motor Engines, Gear Boxes, etc., or parts of same.—THE COMMERCIAL & MARINE ENGINE CO., LTD., Oak Works, Hanwell, W. 7. C 4

Firm of Liverpool Engineers with city office, DESIRE to REPRESENT First-class Manufacturers of Ship Auxiliary Machinery, Hoisting and Lifting Machinery, Malleable Iron and Steel Castings and Forgings.—Address, C 216, Offices of ENGINEERING.

Drawing.—Two Practical MECHANICAL DRAUGHTSMEN are prepared to undertake privately, DESIGNS, CALCULATIONS and DETAILED DRAWINGS for firms or individuals, terms moderate.—Address, C 504, Offices of ENGINEERING.

Canadian Shipyard Visiting Representative can OFFER Canadian built TONNAGE for 1920 delivery.—Address, C 468, Offices of ENGINEERING.

Gas and Oil Engine Repairs.—H. J. DAVIS & CO., Great Eastern Road, Stratford, E. 15.
Tel.: 736 and 737 Stratford.
Gram.: Rapidising, London. 1794

Wanted.—Thorough Practical ENGINEER, Designer and Inventor, will be pleased to UNDERTAKE the DESIGN of plants and detail work, and also superintend the manufacture and erection; having extensive experience in treating with minerals, metals, air, water, &c., with electric portion in connection.—Apply, FRANK H. PLUMB, 18, Colquitt Street, Liverpool. C 445

The Owner of Patent No. 768 of 1914, relating to "Improvements in Axle and the like Bearings," is DESIROUS of negotiating with interested parties for the GRANTING of LICENCES thereunder on reasonable terms.—For information apply to Messrs. LLOYD, WISE & CO., Chartered Patent Agents and Consulting Engineers, No. 10, New Court, Lincoln's Inn, W.C. 2. C 482

The Proprietor of British Patent Numbers 101289 and 101291, both dated August 20th, 1915, relating to "Improvements in Street-Sweeping Machines," and "Improvements in Dust Collectors," respectively, is DESIROUS of ENTERING into ARRANGEMENTS by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patents and ensuring their practical workings in Great Britain.—All inquiries to be addressed to B. SINGER, 29, So. La Salle Street, Chicago, Illinois. C 449

Agents Wanted.

MOTOR WORKS, Manufacturing Two-stroke Crude Oil Engines, for marine as well as stationary purposes, sizes from 10 to 240 B.H.P. types of 100 B.H.P. and upwards direct reversible by compressed air,

WANT to COMMUNICATE

with First-class FIRMS all over the Empire, regarding Agency.

Address, C 374,

Offices of ENGINEERING.

MILLARS' TIMBER & TRADING COMPANY, LIMITED.
Capital Authorised £2,000,000. Issued £1,700,000.

The Company having Branches in India, Australia, New Zealand, Tasmania, Africa, and other countries, would be glad to enter into correspondence with first-class Manufacturing Firms with a view to representing them as AGENTS for the Sale of their Products, and to act as DISTRIBUTING AGENTS in all or any of the above countries.

Agencies are particularly desired for Steam Engines, Tractors, Oil Engines (for crude and refined oils), Pumping Plant including Centrifugal Pumps for Irrigation, Agricultural Implements, Sawmill Machinery; Hair, Leather and Balata Belting; Rubber Goods, Oils, Paints and Varnishes; also all kinds of Engineering Timbers.—Address, Pinners' Hall, Great Winchester Street, E.C. 2. C 290

Sand Papering Machine, Single Drum with Roller Feed, 24 in. size (Oliver No. 29 preferred). Give full particulars and price.—Address, C 464, Offices of ENGINEERING.

Wanted.—Steel Plates from 3-10, 6-10, 7-10 mm. and up.
TIN PLATES of 90-100, 23-100, 37-100, 50-100 of mm. and up.
GLASSES for Windows.
PORTLAND CEMENTS, etc.
Offers by largest quantities are wanted by M. HENRI RAVEAU, C 477
44, Rue de Dunkerque, Paris.

A Time Recorder Wanted, State price and where can be seen.—BOX T.R., SMITH'S Advertising Agency, Ltd., 100, Fleet Street, London, E.C. 4. A 679

London Scottish Engineers, LIMITED.

WORKS comprising
PLANING, TURNING, BORING, GRINDING MACHINES, &c.,
ASSEMBLING SHOPS,
are
OPEN to ACCEPT CONTRACTS,
viz.,
Special Machinery.
Electric and Hand Winches.
Automobile and Engine Parts on Mass Production.
Gun Metal and Iron Castings.
Cast Iron Brazing (special process).

Quotations on receipt of Drawings.

LONDON SCOTTISH ENGINEERS, LTD.,
Magnet Wharf,
Bow Bridge, E. 15.
Telephone: Stratford, 791. B 770

Number of Brown & Sharpe AUTOMATICS REQUIRED, sizes 00 or 000. Must be in first-class condition. Full particulars regarding price, etc., to be sent.—Address, C 214, Offices of ENGINEERING.

Number of Double-action DRAWING PRESSES REQUIRED for large and small work. Must be in good condition. State full particulars.—Address, C 215, Offices of ENGINEERING.

Wanted, 15 cwt. Motor-driven PNEUMATIC HAMMER.
Also Two BLACKSMITH'S HEARTHS, about 5 ft. square, and FANS, or one Fan for both Hearths. Address, C 466, Offices of ENGINEERING.

Steam Hammer Wanted; three, four or five tons, second-hand in good condition; for immediate delivery. State lowest price and full particulars.—Address, C 465, Offices of ENGINEERING.

Wanted, Type 4a Shearing MACHINE, by Collier & Co., Detroit, U.S.A. Capacity ½ in. plates.—Price and where inspected to BOX 99, WHEELER'S Advertising Agency, Manchester. C 487

Wanted, Taylor's Rotary CUTTING-OFF MACHINE, also COLD SAWING MACHINE, 36 in. Blade for Cutting M.S. Sections.—Address, RUBERY, OWEN & CO., Darlaston. C 474

Wanted, One Double Winding ENGINE, about 13 in. by 24 in., with drums 2 metres diameter.—Give full particulars and price.—Address, C 475, Offices of ENGINEERING.

AUCTION SALES.

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD
(PLANT AND MACHINERY SECTION).

Important Sale of

VALUABLE MACHINE TOOLS
and
ELECTRIC MOTORS.
(The NATIONAL PROJECTILE FACTORY, TINSLEY "B" PLANT.)

At the Works of Messrs THOS. FIRTH & SONS, LTD., Weedon Street, Tinsley, Sheffield.

On THURSDAY, JANUARY 22nd, at Eleven a.m.

Comprising:—
16 13 in. Centres Boring, by Tangyes, Ltd.
15 12 in. Centres Sliding and Surfacing Turret, by Darling & Sellars.
12 12½ in. Centres Self-acting, Sliding, Surfacing and Screw-cutting, by Stirk & Sons.
Eight 12½ in. Centres Self-acting, Sliding and Screw-cutting, by Parkinson & Son.
Eight 10½ in. Centres Sliding and Surfacing, by Carter & Wright.
Six Sliding and Surfacing, by Ryder & Son.
Two 22 in. Heavy duty New Century Drilling Machines, by Jones & Shipman.
Two 10½ in. Patent Bar Cutting-off Machines, by Clifton & Baird.

Also 60 ELECTRIC MOTORS (D.C. 230 volts).
16 15 HP., by The British Thomson Houston Co.
15 10 HP., by The Phœnix Dynamo Co.
Two 10 HP., by The Westinghouse Co.
27 7½ HP., by The British Thomson Houston Co., with Starters and Switches.

On view MONDAY, TUESDAY and WEDNESDAY, JANUARY 19th, 20th, 21st, from 10 to 3 o'clock.

ADMISSION BY CATALOGUE ONLY.

Catalogues, 1/- each, on application to the Auctioneers,
Messrs. HADON & LOCKWOOD,
St. James Street, Sheffield. Telephone, Central 111. Telegrams: Weedon, Sheffield.

NOTE.—For particulars of other Government property for sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. C 430

Wheatley Kirk, Price & Co.
(Established 1856).

Auctioneers
AND VALUERS OF 7372
ENGINEERING WORKS PLANT AND STOCK,
46, WATLING STREET, LONDON, E.C.
16, ALBERT SQ., MANCHESTER. 36, COLLINGWOOD ST., NEWCASTLE-ON-TYNE.
Telephones & Telegrams at each Address.

Liquidation of the LTED. Society "LA TRANSMISSION UNIVERSELLE FRANCAISE."—PATENTS concerning especially machines for transmitting rotary power at variable speeds "WILLIAM & JEANNEY" SYSTEM; (some rights of manufacture under the said patents being reserved). TO BE SOLD by AUCTION at the Office of M. DUFOUR, Notary in Paris (France), boulevard Poissonnière, N. 15, on January 28th, 1920 at p.m. Upset price (that may be lowered) 100,000 francs. Deposit of 5,000 francs for bidding. Apply to the Notary and to M. BERNET-ROLLANDE, Liquidator, 46 rue Notre Dame de Loretto, Paris. C 326

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD
(PLANT AND MACHINERY SECTION).

GREAT SALE BY AUCTION
of the Whole of the
HIGHLY IMPORTANT AND VALUABLE MODERN ENGINEERING AND HYDRAULIC FORGING PLANT,
At the NATIONAL PROJECTILE FACTORY, DUDLEY (WORC.),
On
MONDAY, JAN. 5th, 1920, and four following days, and
MONDAY, JAN. 12th, 1920, and four following days,
Commencing at 10.30 a.m. each day.

Comprising—
75 B.W. ELECTRIC MOTORS, 100 HP. to 2½ HP., and starters.
7000 ft. run 3½ in. and 4½ in. M.S. SHAFTING and PULLEYS.
336 HERBERTS LATHES, Nos. 3 to 17.
62 BOYE and EMME S.S and S. LATHES, 10 in. Centres.
70 Valuable S.S. and S. LATHES, 18 in. to 6½ in. Centres,
by Swift, Pratt & Whitney, American Tool Co., Ryerson, Reed, Barker, Bremner, Fay & Egan, Milwaukee, Stevens, Lang, Redman, Drummond and others.
400 S. and S. LATHES, 10 in. to 8 in. Centres, by Denham, Louden, Ormerod, Dorman, Clay, Holman and others.
A SHLSON Rapid Precision LATHE, 6 in. Centre.
Relieving LATHES, by Smith & Coventry, Rencker, and Holroyd; an ALMM CAPSTAN No. 2; Crank Turning LATHES, etc.
40 Plain and Universal MILLING MACHINES, by Le Blond, Brown & Sharpe, Cincinnati, Hendy, Fox, Kendal, Becker, Pratt & Whitney, Van Norman, Kempsmith, Cocksaw, Renecker and others.
Five RADIAL DRILLING MACHINES, by Carlton, Style S. 36 in., Fordeck 30 in., Asquith 4 ft. 6 in., etc.
50 DRILLING MACHINES, one, two, three and four Spindles,
by Herbert, Baker, Superior Machine Co., Jones and Shipman, Reed, Alexander, Rockford and others.
13 JONES & SHIPMAN 30 in. VERTICAL DRILLING MACHINES.
A WEBSTER & BENNETT 18 in. DUPLEX BORING MILL.
Two STIRK PLANING MACHINES, 16.0 by 5.0 by 5.0, Motor Driven, and One BUTLER'S H.S. PLANER, 6.0 by 2.0 by 2.0, and gear.
40 SLOTTING and SHAPING MACHINES, by Steptoe, Selson, Perkins, Sayer, Wilkinson, Herbert, and Butler.
A LA POINTE No. 3 BROACHING MACHINE, for Keyways 1½ in. square by 6 in. long.
15 Valuable GEAR GENERATORS and CUTTING MACHINES,
by Brown, Barber & Colman, Brown & Sharpe, Gleason, Holroyd, Fellows, and Newark Co.
Six Four Spindle AUTOMATIC MACHINES, by New Britain Co. No. 20, Cleveland 2½ in. and 2½ in., and Potter & Johnson No. 8a.
12 THREAD MILLERS, by Archdale & Arundel; 24 parting off LATHES, for 9½ in. to 6 in. bars, by Butler, Holroyd, Heap, Hurlbert & Rogers, Racine Co., etc.
40 Various Plain and Universal GRINDERS, with and without Magnetic Chucks, by Churchill, Landis, Heald, Norton, Taft Pierce, Herbert, American Tool Co., Brown & Sharpe, and others.
65 Various PERIPHERY and CUP GRINDERS, by Lumsden, Baxter, Whitney, Harper, Sons & Bean, Ltd., and others; Nine various Tool and Twist Drill GRINDERS, a De Whitton Centering MACHINE; Bar Testing and Straightening MACHINES; a Herbert Screw Dia. Measuring Machine, an East Ferry Co.'s Testing Set, Oil Testing Tables, Demagnetising Set with Generator, by Humphries; a Template CUTTING MACHINE, Three Blanking and Piercing PRESSES, by Taylor & Challen; 12 Sawing MACHINES, 12 in. to 6 in. stroke, Eight FLY PRESSES.
Three 200 ton DAVY SHELL NOSING PRESSES, to 1500 lbs.
Shell Furnaces, Alexander Riveting Machines, a Three cwt. Drop Stamp, Ground Arbor Presses, Ackworth Tappers, Marking Out Tables.
Nine AIR COMPRESSORS,
by Bryan Donkin, Ingersoll, &c.; Sand Blast Plant by Tilghman (Room type).

The VALUABLE HYDRAULIC PLANT,
Six SETS DAVY'S 200 HP. Three-Throw PUMPS, 4½ in. by 15 in. Stroke,
each coupled direct to a 200 HP., protected type, Slip-Ring Motor and Auto Contactor gear complete.
Two BERRY'S ACCUMULATORS for 1500 lbs. breaking pressure.
Two DAVY'S STEEL AIR VESSELS, 20 ft. by 8ft., breaking pressure 60 lbs. to square inch.
Two WORTHINGTON'S Duplex STEAM PUMPS, 5½ in. by 8½ in. by 8 in., 200 gallons capacity.
Five 300 ton DAVY'S HYD. DRAWING AND PIERCING PRESSES.
3000 feet HP. HYD. MAINS, 4 in. to ½ in. and Fittings, and 1200 feet Return Mains.
THE FORGE PLANT,
comprising 10 three-door Gas Fired Flat Hearth Reverbatory Furnaces, 9 ft. by 4 ft. 6 in., with Gas and Air Valves and W.I. Stack, 60 ft. by 2 ft. 6 in. diameter.
Three WINCOTT'S WRANDALL Gas Fired Sloping Hearth Furnaces, 15 ft. by 4 ft. with 5 in. Ram Hydraulic Charging Plungers, and W.I. Stacks.
4100 square feet C.I. FLOOR PLATES, 1½ in. thick.
LANCS BOILER, 30 ft. by 8 ft., by H. and T. Danks.
A Two-Girder Three-Motor Type ELECTRIC OVERHEAD 5 Ton TRAVELLING CRANE, 46 ft. 4 in. span, by Holt & Willetts.
Two Two-Girder Three-Motor Type ELECTRIC 3 ton CRANES, by Babcock & Wilcox.
Two Motor-Type "WALKERING JIB CRANE," 15 ft. radius, to lift 1½ tons.
Two Motor-Type ELECTRIC RUNWAY HOISTS, 1½ ton, by Herbert Morris, Ltd.
Two ELECTRIC JIB CRANES, to lift 1 ton, with Motor Drive.
THE GAS-PRODUCING PLANT,
Four No. 4 size WINCOTT Water-Bottom GAS PRODUCERS,
capable of gasifying 12 cwt. coal per hour; Hor Steel Cornish Firing Boiler, 18 ft. by 6 ft., and Heater, by Danks; three Keith & Blackman Belt-Driven Narrow Patt. Blowers, 3 in. outlet, 2000 revs. and pipe connection;
THE HARDENING AND HEAT TREATMENT PLANT,
with Ammonia Compressors; Pyrometers, Gas Fired Furnaces and connections; a Monometer Oil Fired Melting Furnace, 500 to 800 lbs. capacity, and 36 Plumbago Crucibles; Acetylene Welding Plant, Pipe Fitters' Plant, Carpenters' and Pattern Shop Contents;
Four ELECTRICAL TRUCKS and CHARGING PLANT,
THE CONTENTS OF SMITHY,
consisting of nine Single and Double Climax Hearths and Blowers, two Smiths' Hammers 7 cwt. and 3 cwt. capacity; Anvils, Swages, Stands, Tools, Bosbes, &c., Pneumatic Lift Hoists, Slurry Mixing Plant, Oil Storage Tanks, 600 and 1000 gallons capacity, and Pumps.
A BUCKTON'S 30 ton VERTICAL TESTING MACHINE,
a small Hydraulic Testing Machine, Measuring Machine up to 4 m.m., by Cambridge Scientific Co., Ventilating Fans, Six Valuable Motor-driven Creeper Conveyors, by Gibbons; a large quantity of useful Machine Parts, Avery's Portable Weighing Machines, Hyde Acme Blocks and Chains.
Ambulance Room Contents and other Effects, which will be fully described in Catalogues to be had on application to the AUCTIONEERS, Messrs.

Duncan J. Shedden and CHARLES B. ODELL,
at their Offices, 2, Priory Street, Dudley (Tel. 2288), and 53, Hertford Street, Coventry (Tel. 181), or at the National Projectile Factory, Dudley.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all Bookstalls; or by quarterly subscription of 2s., post free, payable in advance to the Director of Publicity, Minister of Munitions, Whitehall Place, London, S.W. 1. C 213

G. R.

BY DIRECTION OF THE DISPOSAL BOARD
(FACTORY DISPOSAL BRANCH).

NATIONAL PROJECTILE FACTORY, DUDLEY, WORCS.

Mr. Duncan J. Shedden with Mr CHARLES B. ODELL are instructed to OFFER for SALE by PUBLIC AUCTION, in one lot, subject to Conditions of Sale to be read at the time, on

MONDAY, JANUARY 5th, 1920,
on the Factory Premises at 10.30 a.m. punctually, immediately preceding the Sale of the Plant and Machinery,

THE IMPORTANT FREEHOLD FACTORY
having a total area of
30,400 square yards or thereabouts,
including
329,000 square feet of covered Floor Space soundly constructed in sections of steel girders and channels with brick fillings, slated and glass roofs and concrete floors, together with

THE ELECTRIC TRANSFORMERS AND WIRING FOR POWER AND LIGHTING,
The Chief Mains of Shafting and Pulleys,
The Heating and Ventilating Plant,
The Gas Meters and Mains for Heat Treatment and Lighting,
The Water Service and Fire Appliances,
The Electric Master Clock and Synchronome Dials with Connections.
The Compressed Air Pipe Service and Hydraulic Mains.
The 15-ton Fixed Weighbridge.
A quantity of Loose Parts, Fittings and Stores for the various Installations, all of which are set out in detail in Printed Particulars and Plans of the Factory now being prepared.
The Factory has been erected within the last four years, is conveniently arranged for the economical handling of material and is divided into substantial and well-lighted Shops of exceptional floor space with galleries and basement of easy access. It is situate in the heart of an extensive manufacturing area with an ample supply of labour available. An abundant supply of fuel and electrical power are obtainable. Within easy distance of the goods depôts of the London & North Western, Midland and the Great Western Railways.
The Property is offered in one lot with an equipment which permits of an immediate resumption of work. It is one of the most important and attractive factories in the Midland area.
Plans, "ground floor and elevations," with full particulars may be obtained on application to THE CONTROLLER, Lands and Factories Section, Disposal Board, Charing Cross Building, Embankment, London, W.C. 2; of the Auctioneers at their offices, 2, Priory Street, Dudley (Tel. 2288), and 53, Hertford Street, Coventry (Tel. 181), or at the National Projectile Factory, Dudley (Tel. 2495).
C 269

Auction Sales, &c., continued on page 148.

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD.
(PLANT AND MACHINERY SECTION.)

HIGHLY IMPORTANT

Sale by Auction of

MACHINE TOOLS,
SHEET METAL WORKING MACHINERY,
WOODWORKING MACHINERY,
ELECTRIC MOTORS,
LOOSE TOOLS,
and
MISCELLANEOUS PLANT.
(The whole of which are practically new.)
At the NATIONAL AEROPLANE FACTORY,
AINTREE, near LIVERPOOL.

On TUESDAY, JANUARY 13TH, 1920,
and Following Days,
At ELEVEN o'clock prompt each day.

Comprising briefly:—

MACHINE TOOLS.

Eight No. 1 Capstan LATHES, by Warney and Swasey, and one No. 2 Ditto Herbert Precision Screw Lathe, maximum diameter 2½ in.

Four 4-Spindle ACME AUTOMATICS Nos. 53, 55 and 56.

Four Auxiliary SCREWING MACHINES to screw from 4 B.A. to ⅞ in. thread by National Acme Company.

Plain Horizontal MILLING MACHINE No. 25, by Bolton Machine Tool Co.; Universal "Milwaukee" Milling Machine No. 1 B; Van Norman Duplex Milling Machine with table 35 in. by 10 in.

Milwaukee SHAPING MACHINE, 20 in. stroke.

SLOTTING, DRILLING and KEY SLOTTING MACHINE to cut Keyways 20 in. long by 1 in. wide.

Le Blond No. 1 UNIVERSAL Grinder, Churchill Universal Grinder, two Magnetic Chucks.

Circular METAL CUTTING SAW to cut up to 8½ in. round by Nutter and Barnes.

Seven New Century Bench DRILLING MACHINES, 10 in. by 14 in., by Jones & Shipman. Five Vertical Pillar Drilling Machines, 14 in., by Jones & Shipman No. 2 Vertical Drilling Machine by Knight. Die Filing Machine, Hack Saw Blade Sharpener.

18 Portable ELECTRIC DRILLS, capacity ½ in., by Black & Decker.

SHEET METAL WORKING MACHINERY.

Two 50 ton Geared INCLINABLE POWER PRESSES, 2 in. stroke, by Rhodes. Two 20 ton Ditto. Hand Screw Press. Six Arbor Presses. Shaft Straightening Press.

Two Power Guillotine SHEARING MACHINES, to take 6 ft. and 4 ft. One Treadle ditto, to take 20 W.G., two Rotary Shears, No. 3 Size, heavy type to cut 3/16 in. steel, by Oliver.

Two Automatic POWER HAMMERS, Nos. 11 and 12, for beating Sheet Metal.

Three POLISHING and BUFFING MACHINES.

Four "Linisher" Surface GRINDING MACHINES, Globe Tool Grinder, Bar Straightening and Reeling Machine to take ⅜ in. to 1½ in. bar. Tube Cutting Machine to take ⅛ in. to 3 in. tubes. Three Speed Template Cutting Machine, 29½ in. gap, 3/16 in. sheet. Two Pettingell No. 2 Planishing Hammers, Hand Shearing and Punching Machines, Angle Benders, Sheet Metal Folders, Sheet Roller and Bending Machines, Beading Machines, Tube Bending Machines, &c.

WOODWORKING MACHINERY

by Robinson, Sagar, Haigh, Wadkin, Oliver and White.

ROLLER FEED SAW BENCH to take 42 in. Saws, Plain Saw Bench to take 26 in. Saws, Two Canting Table Dimension Saw Benches to take 16 in. Saws. Lath Sawing Machine, with roller feed to take 18 in. saws, Band Saw 30 in. Pulleys. Seven Jig and Fret Saws, 2 ft. 6 in. square table with blower and boring attachment.

MECHANICAL WOODWORKER direct coupled to 8/4 HP. Motor.

Two 4 Cutter PLANING and MOULDING MACHINES to take 9 in. by 4 in. and 9 in. by 5 in. Four Double Spindle Vertical Moulding Machines and one Single Spindle Ditto.

Three High Speed ROUTING, CARVING, and RECESSING MACHINES, with tables 30 in. by 24 in. and 30 in. by 14 in.

Six Vertical BORING MACHINES, 6 in. to 9 in. feed. Double Boring and Blocking Machine.

Five Automatic Propellor SHAPING MACHINES for 12 ft. and 14 ft. propellors, Disc, Bobbin and Single Belt Sanders. 15 in. Surfacing and Planing Machine.

16 in. PLANING and THICKNESSING MACHINE, 12 in. Surfacing and Thicknessing Machine.

Combined COPYING and GRINDING MACHINE, 8 ft. 6 in. between centres. Two Universal Wood Trimmers. 16 Glue Heaters. Circular Saw Setter, Band Saw Rolling Machine, &c.

77 ELECTRIC MOTORS.

3-Phase, 50 periods, 460 volts, squirrel cage and slip ring type from 2 to 30 HP., by Westinghouse, with starters and switches.

MISCELLANEOUS PLANT.

Seven Centrifugal Oil Separators, Two Enamelling Stoves, three Dipping Baths, Brazing and Smith's Hearths, Tilghman's Sand Blast Apparatus, two Acetylene Generators, Acetylene Plant, 300 cub. ft. per hour capacity. Three Fletcher Russell Blowers, 3 in. delivery, Robinson's Electrical Engraving Machine, Pyrometers.

25 Ton UNIVERSAL AVERY TESTING MACHINE, for tensile, compression and bending tests with autographic stress strain recorder. One 20 ft. pounds Izod's Impact Testing Machine. Three Photo Printing Machines, 12 Single Needle Singer Sewing Machines, three Double ditto, and two Treadle ditto.

Two BELT-DRIVEN PORTABLE CONCRETE MIXERS, 12 cub. ft. capacity, with elevating skips and water tanks.

LOOSE TOOLS, &c.

Including MICROMETERS of all sizes by Starrett, Slocomb, Almond, and Brown & Sharpe.

Steel Try Squares, Straight Edges, Rules, Surface and Depth Gauges, Dial Test Indicators, Levels, Clinometers, Vernier Callipers, Dividers, Newall Plug Gauges, Bevels, Trammels, Clamps, Radius Gauges, Steel Tapes, Bevel Protractors, Spring Dividers, Wire Gauges, Goggles, Respirators, 600 reels Sewing Cotton (white, black, khaki and green), Tables, Counters, Chairs, Stoves, Brushes, &c.

On View Monday, January 12th, or previously by written order.

For further particulars and catalogues (PRICE 2s. each), apply to the Auctioneers,

GEO. N. DIXON & CO.

at their offices, 41, Castle Street, Liverpool. Telephone 3853 Bank. Telegrams: "Tenacity"; and 23, Northumberland Avenue, London, W.C. 2. Telephone 2395 Regent. Telegrams "Valdixaue, Westrand."

NOTE.—For particulars of other Government property for sale, see *SURPLUS*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance, to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. C 311

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD
(PLANT AND MACHINERY SECTION).

Sale by Auction of

MACHINE TOOLS,
NEW HYDRAULIC SHELL-TESTING APPLIANCES WITH INTENSIFIERS AND MISCELLANEOUS PLANT,
at the
GOVERNMENT BOND DEPOT 1208,
QUEEN'S DRIVE, WALTON, LIVERPOOL.

On FRIDAY, JANUARY 9TH, 1920, at 11 o'clock prompt.

Comprising:—

16 S.S. and S.C. LATHES, 13 in. Centres, by Niles, Bement & Pond.

14 S.S. and S.C. LATHES, 12 in. Centres, by J. H. Wilson & Co.

13 Shell Boring LATHES, 13 in. Centres, by Ward, Haggis & Smith.

Eight S. and S. LATHES, 12 in. Centres, by Bridgeford.

19 4-Tool Turret LATHES, 9 in. Centres, by Asquith.

Nine 6-Tool Turret LATHES, 9 in. Centres, by Asquith.

One 4-Tool Turret Lathe, 10½ in. Centre, by Campbell.

No. 3 Cincinnati Vertical MILLING MACHINE.

Five THREAD MILLERS, by Arundel & Delauney Belleville.

Arundel Shell RIVETING MACHINE.

Five-Throw Vertical HYDRAULIC PUMP, 2½ in. rams, 3 in. stroke, by Fawcett, Preston & Co.

6 in. Butler CUTTING-OFF MACHINE.

144 NEW HYDRAULIC SHELL-TESTING APPLIANCES, each with Intensifier, principally by John Shaw & Sons.

Five SHELL-NOSING FURNACES with rotary gear.

Three Keith Blackman AUTO MIXERS, Size 2, 6, Varnishing Stoves, 4 ft. by 5 ft. 6 in. Dwight Slate Marking Machine, Two Seta Beam Scales, Six Computing Scales to weigh 1 cwt.

On View THURSDAY, JANUARY 8TH, or previously by appointment.

For further particulars and Catalogues (Price 1s. each) apply to the Auctioneers,

GEO. N. DIXON & CO.,

at their Offices, 41, Castle Street, Liverpool, Telephone 3853 Bank, Telegrams "Tenacity"; and 23, Northumberland Avenue, London, W.C. 2, Telephone 2395 Regent. Telegrams "Valdixaue Westrand."

NOTE.—For particulars of other Government Property for sale, see "SURPLUS," price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. C 388

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE SURPLUS GOVERNMENT PROPERTY DISPOSAL BOARD.
(PLANT AND MACHINERY SECTION.)

PRELIMINARY ADVERTISEMENT.

Important Sale by Auction of

VALUABLE MACHINERY AND PLANT,
ELECTRICAL EQUIPMENT,
Office Fittings and Furniture,
At the GRIMESTHORPE WORKS
of
Messrs. CAMMELL LAIRD & CO., LTD.,
SHEFFIELD.
(Within the 60-pounder Shop.)

On MONDAY, FEBRUARY 2ND.

Comprising:—

154 LATHES,

24 Grinding Machines, 27 Drilling Machines, 26 Boring Machines, Cutting-off and Centering Machines, 14 Milling Machines, Screwing Machines, Shaping and Slotting Machines, Presses, Hand Screw and Fly Presses, Polishing Machines, Guillotine Shearing Machines,

46 ELECTRIC MOTORS,
From 2 to 500 B.HP., with Starting Panels and Fittings.

ELECTRIC CRANES,
Two and Five Tons.

HAND JIB CRANES,
Three THREE-THROW HYDRAULIC HORIZONTAL PUMPS,

Accumulators, Air Compressors, Transformers, Sturtevant, Keith Blackman and Burdon Type FANS,

Lead Path Furnaces, Pre-heating Furnaces, Richmond Re-generating Furnaces, Resin Melting, and Sand Blast Plants,

WEIGHING MACHINES,
Auto Weighers, Steel Tanks, Bins, Racks and Tubs.

Large Quantity of
MAIN and COUNTER SHAFTING,
Pulleys, Brackets, Wall Boxes and Pedestals.
LEATHER and BALATA BELTING, WOOD BENCHING, CUPBOARDS, LOOSE TOOLS,
OFFICE FITTINGS AND FURNITURE.
Catalogues in preparation by the AUCTIONEERS,
Messrs. J. J. GREAVES & SONS,
Aldine Court, Sheffield.
Telephone, Central 1116.
Telegrams "Greaves," Auctioneers, Sheffield.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all Bookstalls; or by Quarterly Subscriptions of 2s., post free, payable in advance, to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. C 452

FOR SALE.

Boiler For Sale, Lancashire,

26 ft. by 8 ft., pressure 140 lbs. per sq. in. Complete with fittings.—Address, PERFECTA TUBE CO., Aston, Birmingham. C 483

Heating Boiler and Fittings

FOR SALE, in first-class condition. Being removed to accommodate larger installation. Can be seen in London.—Address, C 509, Offices of ENGINEERING.

Machinery for Disposal.

TANGYE ENGINE (STEAM).
Cyl. 16 in. bore by 33 in. stroke, 30-35 r.p.m., with split plain flywheel 11 ft. diameter, 20 in. face, 7 in. diameter crank shaft.

TANGYE ENGINE (STEAM).
Cyl. 13 in. bore by 28 in. stroke, 90 r.p.m., with rope flywheel, takes 10 ¾ ropes, wheel 10 ft. diameter, 6 in. diameter shaft.

ROBEY VERTICAL STEAM ENGINE.
12 in. bore by 10 in. stroke, 180 r.p.m.

BELT DRIVEN AIR COMPRESSOR, by Schram, Harker & Co., London.
Cylinder in tank jacket bore, stroke 2 ft., 6 ft. diameter by 12 in. face flywheel, heavy section.

One SECOND-HAND HYDRAULIC PRESS.
4 ft. 6 in. stroke, 30 in. ram, working pressure 1200 lbs. per sq. inch. By John Shaw & Co.

One NEW HYDRAULIC PRESS.
4 ft. 6 in. stroke, ram 27 in. diameter, working pressure 1200 lbs. per sq. inch. By John Shaw & Co.

COLBURN DRILLING MACHINE (Second hand).
Rising and falling table, eight spindle speeds, variation traverse, spindle 12½ in. centre from frame.

One LATHE, by Fitchburg Machine Co., U.S.A. (Second hand).
11 in. centre, sliding, surfacing and screw-cutting, hollow spindle, double back geared, three-speed cones, admit between centres 4 ft., overhead countershaft. (No change wheels.)

Three CIRCULAR PARTING OFF MACHINES.
To cut up to 6 in. diameter steel bars.
One Fawcett, Preston & Co.
Two Clifton & Baird, Ltd.

Three 20 in. diameter H.P. SIROCCO FANS, with 8 in. outlet, 8 in. water gauge at 1700 revs. per minute.

Address, C 195, Offices of ENGINEERING.

The following Important

HYDRAULIC PLANT
and
MACHINE TOOLS
available for IMMEDIATE DISPOSAL:—

One 2500 tons Vertical Combined Piercing and Drawing Press.
One Strengthening Block and Head.
Two Hydraulic Intensifiers.
One spare set of Columns.
Four sets of 200 B.HP. Electrically driven three throw Hydraulic Pumps, complete with Starters, etc.
Two Hydraulic Accumulators, Ram 30 ins. dia. by 20 ft. stroke.
One Mild Steel Air Vessel 8 ft. by 30 ft.
Accumulator Service Pipe work, Valves, &c.
High pressure Stop Valves, Low pressure Exhaust Mains, Sluice Valves, Momentum Valves.
One 160 HP. three throw Horizontal Electrically driven Hydraulic Pump, complete with Contactor Gear.
One Berry 60 HP. B.T.H. Motor and Pump, complete with Contactor Gear.
One Rice Accumulator, 9 ft. by 16 ft., complete.
One Receiver 4 ft. by 14 ft. long, complete with all Pipe connections and valves.
One 6 arm 3800 tons Banding Press, complete with valves.
One 6 arm 3800 tons Banding Press, complete with valves.
One 550 ton Shell Banding Press, complete with valves, together with a large quantity of Spare Stop Valves, Operating Valves, Low Pressure Valves, Check Valves, High Pressure Tees, U. Leathers and Packing.
600 ft. of 5 in. HP. Hydraulic Piping.
600 ft. of 6 in. HP. Steam Piping.
512 ft. of 1 in. HP. Hydraulic Piping.
512 ft. of 1 in. HP. Steam Piping.
One Heating Furnace 4 ft. 6 in. by 16 ft., by Richmond, with Hinged Door and Top Plate.
One 1200 tons Pointing Press.
The above plant is in excellent condition, having been in use only a short time.

40 Tangye Lathes, 18 in. by 24 in. Centres with varying lengths of bed, 24 ft. to 54 ft., Sliding, Surfacing, and Screwcutting. All geared heads, Compound, Swivelling Tool Rest, Tail Stocks, Cat head steadies, Former attachments, 4 Jaw Chucks, All direct Motor Driven (Motors detached).
These tools are as good as new.

Also a quantity of Good General Purpose Lathes, from 6½ in. to 12½ in. Centres, by Tangye, Stirk, Lang, Herbert, Ward, Walker, Dean Smith and Grace, London, &c.
One complete 10 ton Broadbent Crane, Span, 38 ft., Electrically driven.
One complete 5 ton Broadbent Crane, Span, 38 ft., Electrically driven.
Full particulars will be supplied on application.
Arrangements for Inspection can be made on application to:—
A. HARPER, SONS & BEAN, LTD.,
(Waddam's Pool Works,
Dudley. C 490

CUPOLA FOR SALE.

One Foundry Cupola, in good

condition, capable of melting four tons of iron per hour. Made by Davies, West Gorton, Manchester. Delivery immediate.—Address, C 456, Offices of ENGINEERING.

For Sale, Pair Compound In-

verted 250 HP. ENGINES, 60 revs. 100 lbs. sq. inch. In good condition.—Apply, DUGARD BROS., LTD., Bridge Street West, Birmingham. C 458

FOR IMMEDIATE DISPOSAL.

The following High Class

MACHINE TOOLS in excellent condition; 40 "Tangye" LATHES, 18 in. and 24 in. Centres with varying lengths of bed from 24 ft. to 54 ft. long; fitted with Sliding, Surfacing and Screw-Cutting Motions. All geared heads. Compound Swivelling Tool Rests, Tailstocks, Cat Head Steadies, Former Attachments, 4-jaw Chucks; all Direct Motor Driven. Motors detached.

These tools are as good as new, only having been running a short time.

Arrangements for inspection can be made upon application to:—
A. HARPER, SONS & BEAN, LTD.,
Waddam's Pool Works,
Dudley.
C 489

Willson Lathes

FOR IMMEDIATE DELIVERY
FROM STOCK.
8 in. Centres Straight Bed Lathes with either 6 ft. or 8 ft. Bed.

Willson Lathes recently brought higher prices for second-hand stock than to-day's quotation brand new from the firm.

SMITH, BARKER & WILLSON & CO.,
Machinery Hall,
North Morton Street, Halifax.
'Phone: 766. Wire: "Lathe" Halifax.

C 478

Chains (Electrically Welded or

hand made) for all purposes; also Chain Fittings, Rings, Hooks, Swivels, Shackles, &c.; Pulley Blocks for use with Chains, Wire Rope or Hemp Rope; Repetition Smithwork and Castings, plain or machined. Reliable quality; prompt deliveries and reasonable prices.—STRINGERS (Cradley Heath), Limited, Cradley Heath, Staffs. 7869

For Sale.—In Good Running

CONDITION:—
Two cylinder compound Robey ENGINES, having cylinders 12½ in. and 20 in. diam. by 26 in. stroke. These engines are designed to give 120 I.HP. with steam at 120 lbs. pressure at the stop valve. Diameter of flywheel 10 ft. by 16 ins. wide, main bearings 6 in. by 12 in.

One Robey, two-cylinder compound vertical ENGINE, suitable for working with a pressure of 120 lbs. per sq. inch at the stop valve, designed to run at 300 r.p.m.

One Lawrence Scott compound wound bipolar GENERATOR, giving 190 amp. at 105 volts., speed 300 r.p.m. direct coupled to above vertical engine on a combined bedplate.

One MAIN SWITCHBOARD with main and circuit switches.

One Newton compound wound direct coupled GENERATOR, 80 amp., 105 volts., 850 r.p.m.

One ditto, running at 800 r.p.m.

One Crossley GAS ENGINE, 10 B.HP., cylinder 8½ in. bore by 15 in. stroke, complete with gas bag, silencer and water tank.

The above may be inspected at any time between 8.30 a.m. and 5 p.m.

Apply—CHIEF ENGINEER,
Watford Manufacturing Co., Ltd.
Delectaland,
Watford. C 319

Marine Engines, Two Sets of

TRIPLES, ready in six months, cylinders, 18½ in., 28½ in., 48½ in. by 36 in. stroke; 180 lbs. working pressure, good for 1300 I.HP.—Apply, DAY, SUMMERS & CO., LTD., Northam Iron Works, Southampton. B 602

Stirk High-Speed Planers,

8 ft. by 3½ ft. by 3½ ft., two tool boxes, motor-driven, heavy model, nearly new.
No. 36 SMITH & COVENTRY PLAIN MILLER, single pulley, nearly new.
BECKER No. 80 VERTICAL MILLING MACHINE, NEW.
ALFRED HERBERT No. 3 VERTICAL MILLING MACHINE.
No. 2 CINCINNATI VERTICAL MILLER, CONE DRIVE.
No. 2 KEMPSMITH UNIVERSAL MILLING MACHINES.
No. 3 ELVERSON HIGH POWER PLAIN MILLER, all gear drive, table 63 by 12½ in.
POLLOCK & MACNAB 23 in. Swing COMBINATION TURRET LATHE.
KENDAL & GENT 18 in. Swing COMBINATION TURRET LATHE, NEW.
GISHOLT COMBINATION TURRET LATHES, 21 in. Swing, with equipment.
GISHOLT 36 in. VERTICAL BORING MILL, nearly new.
BULLARD 30 in. VERTICAL BORING MILL, circular turret, belt feeds.
CHURCHILL 20 by 108 PLAIN GRINDER.
10 by 36 LANDIS PLAIN GRINDER, with camshaft attachment.
NORTON 14 by 72 PLAIN GRINDING MACHINE.
NORTON 6 by 82 PLAIN GRINDING MACHINES.
12 in., 14 in. and 18 in. stroke SLOTTING MACHINES, by MUIR or BUTLER.
14 in stroke by 10 ft. bed Double Headed BUTLER SHAPER.
No. 8A POTTER & JOHNSON CHUCKING AUTOMATICS.
NEW CAPSTANS, AUTOMATICS, PLANERS and SCREWING MACHINES.

JOHN MACNAB (Machinery), LTD.,
HYDE.
Tel. 78 Hyde. 7770

A Time Recorder, as New, guaranteed, latest model. WHAT OFFERS? —A. G. PHILLEY, 149, Farringdon Road, E.C. 1. A 678

Tool Steel (High-Speed and Ordinary Carbon) FOR SALE over 1920. Enquiries invited from buyers of one ton and upwards. — Apply, THE RELIANCE STEEL WORKS, Ltd., Cross Street North, Wolverhampton. C 434

For Sale 5 H.P. Motor, 600 r.p.m., 220 volts, D.C., by Holmes & Co., Newcastle-on-Tyne, with Switch and Starter. Apply, FRANCIS MORTON & CO., Ltd., Garston, Liverpool. C 397

Generating Sets For Sale. Two 400 K.W. 500/550 volt D.C. GENERATING SETS, consisting of "Bellis" Triple Expansion Engines coupled to Westinghouse compound wound Generators. Immediate delivery can be given. THE PHŒNIX ELECTRICAL CO., LTD., 32-36, Broomielaw, Glasgow. C 412

For Sale, Patterns and Draw- INGS of Brick and Tile-making Machinery. Full particulars on application,—Address, C 376, Offices of ENGINEERING.

60 Kw. Direct-Coupled BELLISS-FOWLER STEAM SET, 400/460 volts D.C., 500 r.p.m., complete for use.—BOROUGH ELECTRICAL ENGINEER, Bury St. Edmund's. C 175

Two 50 HP. Ruston Crude OIL ENGINES. One 20 HP. HORNSBY OIL ENGINE. "WE" type GAS ENGINE by Crossley. Two COLONIAL BOILERS by Robey, 100 lbs. w.p. Four 60 N.HP. LOCO TYPE BOILERS, 150 lbs. working pressure. HARRY H. GARDAM & CO., Ltd., Staines. B 926

Offers Wanted for Two HYDRAULIC BALING PRESSES (used for Peat Moss Litter), complete with Tangye pump, pulleys, &c. Can be seen at works dismantled.—Write for order to view, B. BERENDS, JUNIOR, 62/63, Queen Street, E.C. 4. C 362

1200 Tons New Steel F.B. RAILS, 20 lbs. per yard, with Fish-plates and Bolts and 54,000 Steel Sleepers to match for 24 in. Gauge. Send inquiries— THOS. W. WARD, LTD., Albion Works, Sheffield. C 299

FOR SALE.

Six 10 in. centres all geared head, S.S. and S. Lathe, on 8 ft. 9 in. gap bed, by T. Ryder & Son.
Six No. 3 "Ryerson Conradson" High-Power Plain Milling Machines, all geared head.
15 in. stroke Shaping Machine, by The American Tool Works Co.
Two No. 4 Alfred Herbert's all geared head 6½ in. centres Capstan Lathes.
Six 9½ in. centres Double Geared Lathes, on 7 ft. 6 in. straight bed, by Darling & Sellars.
Heavy Horizontal Milling Machine, by Pratt and Whitney.
30 in. Bullard Vertical Boring Mill, with 4-tool turret on cross slide.
38 in. Bullard Vertical Boring Mill, with 2-tool boxes.
14 in. by 15 in. Ormerod Crank Shaping Machine.
12½ in. centre S. S. and S. Lathe, on 15 ft. straight bed, by J. Lang & Co., Ltd.
CATALOGUE of Stock MACHINERY, 2-3000 LOTS, free on application. Inspection invited.
7974
THOS. W. WARD, LTD., ALBION WORKS. Tel. "Forward, Sheffield." SHEFFIELD.

For Sale.—Powerful Horizon- TAL Belt-driven Twin AIR COMPRESSOR, capacity 985 cubic feet.
One Horizontal Steam-driven AIR COMPRESSOR, by Larmuth, capacity 250 cubic feet.
Several Belt-driven COMPRESSORS, capacities from 25 to 150 cubic feet.
Two "Eclipse" Compressed Air ROCK DRILLS, with Swivel Bars and Adjusting Screws.
Two "Ingersoll"-Steam-driven COMPRESSORS, capacities 250 and 285 cubic feet.
RIDDELL & CO., 40, St. Enoch Square, Glasgow.

For Sale.—One Jones and Lamson 24 by 3 FLAT TURRET LATHE.
One Stern's No. 3 WHT GRINDER.
One 10 ton Buckton TENSILE TESTING MACHINE.
Several Sets Roots BLOWERS, with iron revolvers.
One SLIDING AND SURFACING LATHE, 18 in. centres, 24 ft. bed, extending gap.
Two "Gisholt" TOOL GRINDERS.
Six Girder Wall Radial DRILLING MACHINES, 1¼ in. spindles, to drill 1 in. holes.
One Powerful PLANING MACHINE, to plane 24 by 5 by 5 ft.
Powerful Radial DRILLING MACHINE, 3½ in. spindle, 9 ft. arm.
Excellent Side PLANING MACHINE, by Kendall and Gent, 6 ft. by 4 ft., with Motor complete.
One No. 1 Brown & Sharpe "Universal" GRINDING MACHINE.
One "Landis" Plain GRINDING MACHINE, admits 32 in. between centres.
One Belt-driven Pneumatic Power HAMMER, by Alldays & Onions, suitable for planishing or light smith and forging work; equal new.
One "Herbert" Twist Drill GRINDING MACHINE.
One PLANING MACHINE, table 12 ft. 6 in. by 3 ft. 6 in., two Tool Boxes.
One Powerful Vertical SLOTTING MACHINE, 5 ft. 6 in. stroke; 7 ft. revolving table; automatic feeds with high-speed return; makers, Campbells and Hunter, Leeds; approximate weight, 25-30 tons.
One 24 in. Lang's SURFACING AND BORING LATHE.
One Horizontal ENGINE, 8 in. cylinder by 16 in. stroke.
One Pair 9 in. Cylinders Diagonal ENGINES.
One Superior Richards' SIDE PLANER, 6 ft. by 2 ft. 6480
RIDDELL & CO., 40, St. Enoch, Glasgow Square.

Steam (All Types) Boilers. All Sizes 7280
Vertical, Loco., Cornish, Launch, Field-tube; also Air Receivers, Feed-Water Heaters, Cylinders, &c.—THE GRANTHAM BOILER & CRANE CO., Ltd., Grantham.

For Sale.—Practically new HORIZONTAL 3 THROW HYDRAULIC PUMP, 85 gallons per minute, 2240 lbs. pressure, geared to 180 h.p., 440 volt, 25 cycle, 3-phase motor complete with automatic "Contractor" type control panel.—Address, The PHŒNIX ELECTRICAL Co. LTD., 32-36, Broomielaw, Glasgow. B 616

For Sale.—Two 3-throw HYDRAULIC PUMPS with 200 h.p. 460 volt, direct current motors and control gear.—Address, B 618, Offices of ENGINEERING.

Electrical Plant For Sale.

GENERATING SETS, 100 to 1000 Kw., Direct Current; 300 to 750 Kw., 3-phase, 50 periods.
MOTORS, A.C. and D.C, All types, &c., up to 300 HP.
ROTARY CONVERTERS, TRANSFORMERS, &c., &c.
Enquiries solicited for all classes of ELECTRICAL PLANT and MATERIAL. We can often help you out of difficulty.
We are always open to purchase good modern Electrical Plant.
THE PHŒNIX ELECTRICAL CO., LTD., 32-36, Broomielaw, Glasgow. 8030

Hugh Wood & Co., Ltd., DEPT. N., NEWCASTLE-ON-TYNE.
Tel. Add.: "Huwod," Newcastle-on-Tyne.
Tel.: 980 Central, Newcastle-on-Tyne.
Have available for Immediate Delivery,
AUXILIARY HAULAGE GEARS, ELECTRIC, COMPRESSED AIR, or STEAM-DRIVEN.
Several 15 HP. ELECTRICALLY-DRIVEN HAULERS, 500 volts, 50 periods, or alternatively 500 volts, D.C. equipment.
Several 10 HP. ELECTRICALLY-DRIVEN HAULERS, complete with 500 volts, 50 periods, or alternatively 500 volts, D.C. equipment.
Several STEAM or COMPRESSED AIR HAULAGE ENGINES, double drums, cylinders 7 in. bore by 9 in. stroke.
One 3½ ton Jeffrey Electric Accumulator Standard Gauge LOCOMOTIVE.
One 2½ ton Jeffrey Electric Trolley Standard Gauge LOCOMOTIVE.
Also available for Immediate Delivery,
Several "Huwod" Portable Compressed Air-driven CENTRIFUGAL PUMPS.
"Huwod" Pneumatic Pick Axes, Coal Cutter Hose, &c., &c.
Also for Early Delivery,
One 24 in. by 24 in. Jeffrey SINGLE ROLL CRUSHER or BREAKER, having a capacity of, approximately, 70 tons of coal per hour.
One Jeffrey SWING HAMMER PULVERIZER, having a capicity of 60 tons of coal ¼ in. to dust per hour.
Jeffrey Self-propelling WAGON and TRUCK LOADER, suitable for loading coal, coke, sand or similar material. 6975
HUGH WOOD & CO., LTD.

G. R.
MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD
(LANDS, BUILDINGS, AND FACTORIES SECTION).

For Sale by Private Treaty:

NATIONAL SHELL FORGING and CARTRIDGE CASE PRESSING FACTORY, Edge Lane, Liverpool.

To be disposed of in one Lot.
The following is a brief description:—

SITUATION.

Fronting the Main Road from the City to Broadgreen, Huyton, etc., about 2½ miles from the Town Hall.
Goods Station (Edge Hill) 1 mile, and Passenger Station (Edge Lane) ¾ mile.

CONSTRUCTION OF BUILDINGS.

The principal buildings comprise:—

	Ground Area ft. super.
CARTRIDGE CASE FACTORY constructed in steel with corrugated iron walls and roof with continuous skylight	11,770
BILLET FORGE of similar construction	7,800
GENERAL STORES, BOND, EXAMINATION, PACKING, AND DESPATCH ROOMS, Brick walls, wood principals, boarded and felted roof with continuous skylights ...	12,690
OFFICE BLOCK. Timber and corrugated iron construction with felt roof	2,740
MESS ROOM BLOCK	2,800
The remainder include Tool Rooms, Pump House, Joiner's Shop and various auxiliary buildings.	
Total ground area of buildings about ...	51,000 ft. super.

The land is the property of the Corporation of Liverpool, from which a long lease could be obtained by arrangement on favourable terms, for such portion as is required for Factory purposes.
LIGHTING AND POWER—Electric.
WATER—Public Main.
SIDINGS—Private sidings are laid down connecting with the L. & N.W. Rly. The Corporation will require a right of user by arrangement, over the portion forming the connection.
OFFICE ACCOMMODATION—For 74 Clerks.
MESS ROOM ACCOMMODATION—For 166 Persons.

Further particulars and plan may be obtained on application to the Controller, Land and Factories Section, Disposal Board, Charing Cross Buildings, Embankment, W.C. 2.

NOTE.—For particulars of other Government Property for sale see "SURPLUS," price 3d., at all bookstalls; or by quarterly subscription of 2s., post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. C 191

For Sale, Universal Grinding MACHINE by G. H. Reinecker, 60 in. between centres, 16 in. dia. swing over table. Can be viewed in London.—Address, B 263, Offices of ENGINEERING.

For Sale.— MOTOR-DRIVEN PLANING MACHINE, To plane 30 ft. by 30 ft. by 10 ft., four Tool Boxes. Condition as new. Makers, Buckton & Co. Price and particulars from— MURRAY, McVINNIE & CO., LTD., Mavisbank Quay, Glasgow. 7819

Plant for Sale.—24 in. Shaping MACHINE, three 9½ in. LATHES, 48 in. VERTICAL DRILL, ELECTRIC MOTORS, HARDENING STOVES, two unused GRIDLEY AUTOMATICS.—Address, Wm. ASQUITH (1919) Ltd. Highroad Well, Halifax. C 350

Oil Engine, 90 B.HP., Black- stone. FOR SALE, No. 112459, with Tanks complete; recently bought Government Air Factory, Farnborough, but power now insufficient for purchasers' use. New 1916; believe perfect condition and little used. Price £600, Air Factory, Farnborough.—Address, C 317, Offices of ENGINEERING.

An Opportunity Occurs to ACQUIRE a LIGHT ENGINEERING BUSINESS at an inclusive figure. Stock in Trade, Plant, Goodwill (including orders in hand value £6,500), and Freehold premises situated at Sydenham. Owner retiring.—For full details write to R. H. COULING & COMPANY, 4, Southampton Row, London, W.C. 1. C 353

For Sale the Following:— 23 20 HP. 440 volts, 2 phase, 25 periods, slip ring, 710 r.p.m. MOTORS, by Westinghouse, with Itchin pillar starters, almost new; cheap.—ROBERT WALKER, 2, Oswald Street, Glasgow. C 249

For Sale, 375 Built Steel BRIDGE CROSS GIRDERS, 18½ ft. long by 1½ ft. deep by 8½ in. wide. Suitable for collieries, etc. JOHN JACKSON & CO., LTD., Balmoral Street, Scotstoun, Glasgow. C 226

For Sale.—1000 Kw. Turbo SET with Condensing Plant. TURBO ALTERNATOR SET with Surface Condensing Plant, entirely new, for Immediate Delivery.
Steam pressure, 156 lbs.
Superheat 240 deg. F.
Alternator capacity, 1000 Kw.
3300, 550, or 2000 volts.
50 cycles.
3000 r.p.m.
Address, C 126, Offices of ENGINEERING.

Hydraulic Presses For Sale, in good condition. 750-Ton Davy Bros. DOUBLE PUNCH PRESS, 6 ft. daylight, 1100 lbs. per square inch. About 35 tons weight.
Two 150-Ton Shaw Design SHELL PRESSES, 2 ft. 9 in. daylight, 1500 lbs. per square inch. About 10 tons weight.
Drawings may be seen and full particulars obtained on application.
CHLORIDE ELECTRICAL STORAGE CO., LTD., Clifton Junction, Manchester. C 460

Electric Lamps.—Manufac- turers of First-class Tungsten Wire Lamps have FACTORY THROW-OUTS, and odd sizes FOR SALE. Very Cheap, from 1s. 2d. each. Sound delivery guaranteed and good burning. Write for quotations, giving particulars of Voltages and Candle-powers required.—STOREKEEPER, CORONA LAMPWORKS, LTD., Ascham Street, St. Pancras, London, N.W. 5. C 26

500 Kw., D.C. Steam GENERATING SET, by Browett Lindley, Triple Expansion Enclosed Engine coupled to Multipolar Generator 440/500 volts.
Two 170 Kw. BELLISS SIEMENS GENERATING SETS, 220 volts, 750 amps., 380 revs., Cylinders 12 in. and 20 in. by 10 in. stroke, spare Armature.
One 200 Kw. GENERATING SET by Sissons Peebles, 220 volts D.C., compound wound.
550 HP. HIGH SPEED VERTICAL ENCLOSED COMPOUND STEAM ENGINE, by Bellis, latest type, in new condition.
500 B.HP. HIGH SPEED ENCLOSED COMPOUND STEAM ENGINE, by Allen.
300 HP. TRIPLE EXPANSION OPEN TYPE VERTICAL STEAM ENGINE, by Davey Paxman.
400 Kw. 500 volt D.C. GENERATOR, Rope Drive.
HARRY H. GARDAM & CO., Ltd. Staines. B 925

MISCELLANEOUS.
ON ADMIRALTY LIST.

John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C. 3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Feed Water Filters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 7726

Charles McNeil, Ltd.,
KINNING PARK HYDRAULIC FORGE, GLASGOW.
Makers of Heavy Forged Shafting
7611 Turbine Wheels, Motor Car Stampings.
SEND US YOUR ENQUIRIES.

THE HULL GENERAL PATTERN-MAKING WORKS,
58, Strawberry St., Drypool, HULL.
Quotations given for every description of PATTERN MAKING for Engineers, Iron and Steel Founders, Shipbuilders, &c. 7981
ON ADMIRALTY LIST. Central Telephone 107 Y

BELLISS & MORCOM.
BIRMINGHAM, LTD.
Self-lubricating Steam Engines, Turbines, Air and Gas Compressors, Condensing Plants, Crude Oil Engines and Paraffin Engines
See illustrated Advt. every month. 4566

J. BRUNDRIT 14 Water St. LIVERPOOL

THE SCOTTISH
STAMPING & ENGINEERING CO. LD.,
Drop Forgers and Stampers,
NEPTUNE WORKS, AYR.
See last and next week's Illustrated Advert.

BURCKHARDT ENGINEERING WORKS
Compressors & Vacuum Pumps.
26, VICTORIA ST., WESTMINSTER, S.W. 1.
Works: BASLE, SWITZERLAND. 8098
See Illustrated Advt. alternate weeks.

STRUCTURAL & MECHANICAL
DESIGNING ENGINEERS
Imperial Engineering Service,
60, Mark Lane, E.C. 3. Tel. 6309 Avenue.
Modern Designs, Neat Tracings. Clear Details. 8124

7237

"GUNTHER'
FANS
For Forges, Cupolas, &c.
CENTRIFUGAL
PUMPS.
W. GUNTHER and SONS,
CENTRAL WORKS, EDMONTON. 7918

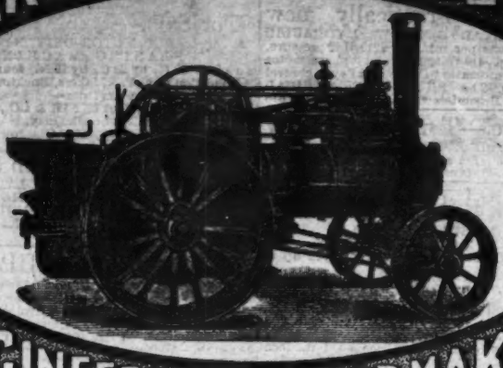
RICHARD INDICATOR.
RELIABLE BOURDON STEAM GAUGES
High Speed Indicators.
BUCHANAN'S ENGINE COUNTERS.
Engineering Instrument Manufacturers.
HANNAN & BUCHANAN
78, Robertson St., GLASGOW. 6452

French, Belgian and English
MOULDING AND SILVER SANDS.
8076
For prices apply to—
HENRY MEAD & CO. Ltd.,
Princes Dock Chambers, HULL.

HEAD OFFICE AND WORKS:—
GAINSBOROUGH, ENGLAND.
LONDON DEPOT:—
79, Farringdon Road, E.C.1.

INDIAN BRANCHES:—
Calcutta, Bombay, Lahore, Madras.
CANADIAN DEPOT:—
Saskatoon, Sask.

MARSHALL SONS & Co LTD



ENGINEERS AND BOILER MAKERS

MANUFACTURERS OF
TRACTION ENGINES,
ROAD LOCOMOTIVES,
STEAM TRACTORS.

Special types for
DIRECT-TRACTION PLOUGHING,
COLONIAL TRANSPORT, and
AGRICULTURAL SERVICES.

8369

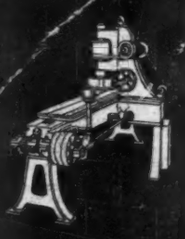
BRIGHT COMPRESSED
SHAFTING
3674
ROUNDS. HEXAGONS. FLATS. SQUARES.
KIRKSTALL FORGE CO., LTD., NEAR LEEDS.

LUKE & SPENCER Ld
CANAL ENGINEERING WORKS
ALTRINCHAM

UP TO DATE
TOOL GRINDING
NO SPLASHING

EMERY WHEELS

MACHINES
FOR ALL
PURPOSES



HIGHEST QUALITY
CORUNDUM WHEELS.

8328

REDPATH, BROWN & CO., LTD.

COMPLETELY EQUIPPED WORKS AND STOCKS AT FOUR CENTRES FOR THE FABRICATION OF ALL CLASSES OF STEEL STRUCTURES AND FOR QUICK DELIVERY.

SPECIALITY—SUPPLYING STRUCTURAL STEEL WORK FROM STOCK MATERIAL WHICH ENSURES QUICK DELIVERIES.

DESIGNS AND ESTIMATES PREPARED BY EXPERT TECHNICAL STAFFS FOR STEEL FRAMED BUILDINGS, STANCHIONS, GIRDERS, ROOFS, BUNKERS, ETC.

EDINBURGH. Registered Office: 2, St. Andrew Square, St. Andrew Steel Works, Albion Road.
GLASGOW. Office: 19, Waterloo St. Works: North Canal Bank St., Port Dundas.
LONDON. 3, Laurence Pountney Hill, Cannon St., E.C. 4. Riverside Works, East Greenwich, S.E. 10.
NEWCASTLE. Milburn House.
MANCHESTER. Westinghouse Rd., Trafford Park.
BIRMINGHAM. 47, Temple Row.

7914

STRUCTURAL ENGINEERS & STEEL MERCHANTS

Printed for the Proprietors by HARRISON & SONS, at the Bedford Press, 20 & 21, Bedfordbury, in the Parish of St. Martin's-in-the-Fields, and Published by CHARLES ROBERT JOHNSON, at the Offices of ENGINEERING, 35 & 36, Bedford Street, in the Parish of St. Paul, Covent Garden, both in the County of Middlesex.—December 26th, 1919.